

Population study on endemic trees and shrubs in Grasslands of Nilgiris Forest Division

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ARTICLE DETAILS

Article History

Published Online: 15 September 2020

Keywords

Diversity, Endemic angiosperms, Exotic weeds, Grassland, Nilgiris.

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ABSTRACT

Undisturbed Grassland is a paradise for endemic species in Nilgiris. However the number of endemic species is not as diverse by the invasion of exotic and the placement of plantation. In order to maintain the volume, diversity and density of all the endemics of this area, there is a need to develop interspecies relationships which are very important to conserve biodiversity. Grasslands preserve their diversity by their association; because of this association endemic species survive in this that habitat. Introduction of species like *Acacia mearnsii*, *Lantana camara*, *Chromolaena odorata*, *Pteridium aquilinum*, *Cestrum aurantiacum*, *Cytisus scoparius*, *Ulex europaeus*, *Ageratina adenophora* disturb the endemic species population in grasslands of Nilgiris. The major population of exotic weeds spoils the succession and survival of endemic species. This comparison study between virgin and disturbed grassland reveals the habitat loss of endemic plants in Nilgiris Forest division. As per result. Totally 61 species of trees and shrubs found in Disturbed grassland, 79 species of trees and shrubs found in undisturbed grassland. 16 endemic angiosperms were recorded in the study area.

1. Introduction

Endemic plants are the unique feature of grasslands. Undisturbed grasslands are known for the endemic plants diversity. These grasslands helped the survival of endemic plants by the upkeep of inter species relationships. According to Nayar (1980) there are 141 genera of angiosperms endemic to India, 25 families are endemic to the Western Ghats, 11 endemic genera occurring in the Nilgiris. 818 endemic angiosperms were to be found in the Nilgiris and adjoining areas (Mohan and Balakrishnan, 1991). Economic activities disturb the species association in grasslands, like the introduction of *Acacia mearnsii* for tannin production, *Eucalyptus globulus* introduced for pulp and paper industry, introduction of *Lantana camara*, *Chromolaena odorata*, *Pteridium aquilinum*, *Cestrum aurantiacum*, *Cytisus scoparius*, *Ulex europaeus*, *Ageratina adenophora* by ornamental plant cultivators. *Acacia mearnsii* (Black wattle) was introduced in the Nilgiris in 1832 by Captain Dun. This has become a serious environmental problem throughout the grasslands of Nilgiris. The plant *Acacia mearnsii* by its colonization has degraded the native biodiversity of grasslands by the release of allelopathic compounds. The outspread of exotic species in grasslands was aided by roads development, commercial clear felling, fire, seed dispersal through animals and birds. Focus of this documentation is on the invasion of exotics in grasslands. The emphasis of this documentation is also on the preservation and conservation of rare endemic threatened angiosperms.

2. Study Area

Grasslands in Nilgiris plateau are divided into two categories for study purpose

1. Undisturbed Grassland
2. Disturbed grassland

Majority of Undisturbed grasslands are way out from urbanized area, which is the Southern part of Nilgiris forest division (Avalanchi, Korakundha, Kundha, PorthiMund).

Disturbed grasslands are near the urbanized area which is the Northern part of the Nilgiris forest division (Ooty, Kotagiri, Coonoor). Here mostly exotic plant species like *Acacia mearnsii*, *Eucalyptus globulus*, *Cytisus scoparius*, *Ulex europaeus* spoils the entire grassland ecosystem



3. Methodology

Trees (> 20 cm DBH) were enumerated from the 10 x 10 m plots. Plots were established with a minimum spatial distance of 100 m and the number of sampling plots per site was decided based on the size of the area and number of species encountered. Saplings and shrubs (< 20 cm DBH and >1 cm GBH) were enumerated from nested subplots of 3 x 3 m established at each corner of the plot (4 subplots/plot).

All plants were identified to species using various regional floras (Fyson 1932; Gamble 1935; Matthew 1999; Hooker 1880; Wight 1849, 1850, 1851; Roxburgh 1832) and online

data base like The Plant List (2013), India Biodiversity Portal (2015), The important quantitative analysis such as density, frequency, and abundance of tree Species, shrubs and herbs species were determined as per Curtis and McIntosh (1950).

$$\text{Frequency} = \frac{\text{Total no of quadrats in which the species occurred}}{\text{Total no of quadrats studied}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Frequency of species}}{\text{Frequency of all species}} \times 100$$

$$\text{Density} = \frac{\text{Total no of individuals of a species}}{\text{Total no of quadrats studied}}$$

$$\text{Relative density} = \frac{\text{Number of individuals of a species}}{\text{Number of individuals of all species}} \times 100$$

Relative cover

$$= \frac{\text{cover of a species}}{\text{total cover of all the species}} \times 100$$

IVI = Relative frequency + Relative density + Relative cover (Rastogi, 1999 and Sharma, 2003),

Species diversity index was calculated using Simpson's index as follows

$$\text{Diversity index } D = \frac{n(n-1)}{N(N-1)}$$

Where: D = diversity index N = Total number of organisms of all species found, n = number of individuals of a particular species,

The value of D ranges between 0 and 1. With this index, 0 represents infinite diversity and 1 no diversity.

$$\text{Species Richness} = S/\sqrt{N}$$

S = the number of different species represented in the sample, N = the total number of species in the sample.

4. Results

Table 1: Important Population Values for Shrub Species In Disturbed Grassland

SPECIES	R.F	R.D	R.C	IVI	S.R
<i>Solanum viarum</i> Dunal	0.04	0.04	0.26	0.33	0.04
<i>Piper schmidtii</i> Hook.f.	0.07	0.07	0.26	0.40	0.08
<i>Psychotria congesta</i> Spreng. ex DC.	0.07	0.07	0.26	0.40	0.08
<i>Strobilanthes wightiana</i> Nees	0.14	0.14	0.52	0.81	0.15
<i>Maesa perrottetiana</i> A.DC.	0.14	0.14	0.52	0.81	0.15
<i>Ziziphus rugosa</i> Lam.	0.16	0.16	0.29	0.62	0.17
<i>Chromolaena odorata</i> (L.) R.M.King & H.Rob.	0.21	0.21	0.63	1.06	0.23
<i>Argyrea hirsuta</i> Arn.	0.21	0.21	0.63	1.06	0.23
<i>Passiflora calcarata</i> Mast.	0.22	0.22	0.65	1.10	0.24
<i>Smilax guianensis</i> Vitman	0.37	0.37	1.07	1.80	0.39
<i>Embelia ribes</i> Burm.f.	0.37	0.37	1.07	1.80	0.39
<i>Senna corymbosa</i> (Lam.) H.S.Irwin & Barneby.	0.37	0.37	1.07	1.80	0.39
<i>Solanum violaceum</i> Ortega	0.44	0.44	1.28	2.16	0.46
<i>Vernonia cinerea</i> (L.) Less.	0.44	0.44	0.92	1.79	0.46
<i>Hypericum mysurense</i> Wall. ex Wight & Arn.	0.44	0.44	0.92	1.79	0.46
<i>Hedyotis leschenaultiana</i> DC.	0.44	0.44	0.80	1.68	0.46
<i>Lantana camara</i> L.	0.51	0.51	0.93	1.95	0.54
<i>Smilax aspera</i> L.	0.55	0.55	1.35	2.46	0.59
<i>Leucas lanceifolia</i> Desf.	0.65	0.65	1.19	2.50	0.69
<i>Baeolepis nervosa</i> Decne. ex Moq.	0.65	0.65	1.19	2.50	0.69
<i>Dregea volubilis</i> (L.f.) Benth.	0.72	0.72	10.60	12.04	0.77
<i>Rubus buergeri</i> Miq.	0.79	0.79	1.46	3.04	0.84
<i>Elaeagnus latifolia</i> L.	0.79	0.79	1.16	2.75	0.84
<i>Elaeagnus conferta</i> Roxb.	0.83	0.83	1.01	2.67	0.88
<i>Solanum robustum</i> H.L. Wendl.	0.87	0.87	1.28	3.03	0.93
<i>Berberis leschenaultii</i> Wall. ex Wight & Arn.	1.09	1.09	1.45	3.63	1.15
<i>Gnidia glauca</i> (Fresen.) Gilg	1.09	1.09	1.45	3.63	1.15
<i>Memecylon randerianum</i> S.M.Almeida & M.R.Almeida	1.40	1.40	5.13	7.94	1.48
<i>Persicaria chinensis</i> (L.) H.Gross	1.40	1.40	5.13	7.94	1.48

<i>Berberis tinctoria</i> Lesch.	1.51	1.51	1.84	4.86	1.60
<i>Rubus niveus</i> Thunb.	1.54	1.54	1.89	4.97	1.63
<i>Sophora velutina</i> Lindl.	1.69	1.69	1.55	4.92	1.79
<i>Rubus ellipticus</i> Sm.	1.76	1.76	2.15	5.66	1.86
<i>Carissa spinarum</i> L.	1.98	1.98	1.82	5.78	2.10
<i>Gaultheria fragrantissima</i> Wall.	2.01	2.01	2.68	6.69	2.13
<i>Ageratina adenophora</i> (Spreng.) R.M.King & H.Rob.	2.10	2.10	1.92	6.12	2.22
<i>Rhodomyrtus tomentosa</i> (Aiton) Hassk.	2.11	2.11	1.93	6.14	2.23
<i>Dodonaea viscosa</i> (L.) Jacq.	5.08	5.08	4.65	14.81	5.38
<i>Scutia myrtina</i> (Burm.f.) Kurz	5.08	5.08	4.65	14.81	5.38
<i>Solanum sisymbriifolium</i> Lam.	7.48	7.48	3.78	18.74	7.92
<i>Solanum mauritianum</i> Scop.	7.48	7.48	6.85	21.81	7.92
<i>Ulex europaeus</i>	19.24	19.24	9.40	47.88	20.37
<i>Cytisus scoparius</i>	25.48	25.48	10.37	61.33	26.97
Grand Total	100	100	100	300	105.86

In disturbed grassland totally 61 trees and shrubs species were found. Table 1, reveals 43 Shrubs (105.86 S.R), (0.12 D.I), *Cytisus scoparius* has highest species richness (26.97 S.R)

Table 2: Important Population Values for Tree Species In Disturbed Grassland

SPECIES	R.F	R.D	R.C	IVI	S.R
<i>Syzygium densiflorum</i> Wall. ex Wight & Arn.	2.00	0.40	1.17	3.57	0.13
<i>Viburnum hebanthum</i> Wight & Arn.	3.00	0.60	1.17	4.77	0.19
<i>Vaccinium leschenaultii</i> Wight	3.00	0.70	1.36	5.06	0.22
<i>Psydrax dicoccos</i> Gaertn.	4.00	0.80	1.17	5.97	0.25
<i>Eurya japonica</i> Thunb.	4.00	1.20	1.75	6.95	0.38
<i>Syzygium calophyllifolium</i> (Wight) Walp.	5.00	1.40	1.63	8.04	0.44
<i>Symplocos cochinchinensis</i> (Lour.) S. Moore	4.00	2.01	2.92	8.92	0.63
<i>Celtis timorensis</i> Span.	9.00	3.41	2.20	14.62	1.08
<i>Rhododendron arboreum</i> Sm.	7.00	4.41	3.67	15.08	1.39
<i>Syzygium cumini</i> (L.) Skeels	11.00	4.41	2.33	17.75	1.39
<i>Scolopia cuneata</i> Warb.	7.00	6.22	5.17	18.39	1.96
<i>Ligustrum perrottetii</i> A.DC.	3.00	6.32	12.26	21.58	2.00
<i>Ixora notoniana</i> Wall. ex G.Don	8.00	6.62	4.82	19.43	2.09
<i>Photinia lindleyana</i> Wight & Arn.	3.00	7.92	15.37	26.29	2.50
<i>Daphniphyllum neilgherrense</i> (Wight)	4.00	7.92	11.53	23.45	2.50
<i>Neolitsea zeylanica</i> (Nees & T. Nees) Merr.	6.00	8.32	8.07	22.40	2.63
<i>Eucalyptus globulus</i> Labill	6.00	8.32	8.07	22.40	2.63
<i>Acacia mearnsii</i> De Wild.	11.00	28.99	15.33	55.32	9.15
Grand Total	100	100	100	300	31.58

Table 2 reveals 18 trees (31.58 S.R), (0.13D.I). Shrubs were most abundant species than trees in Figure 1. *Acacia mearnsii* has highest species richness (9.15 S.R) in disturbed grassland. Figure 2 reveals lowest species richness of trees in undisturbed grassland.

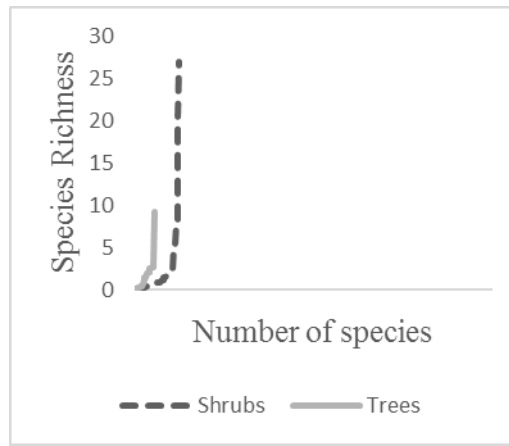


Figure 1: Species richness in disturbed grassland

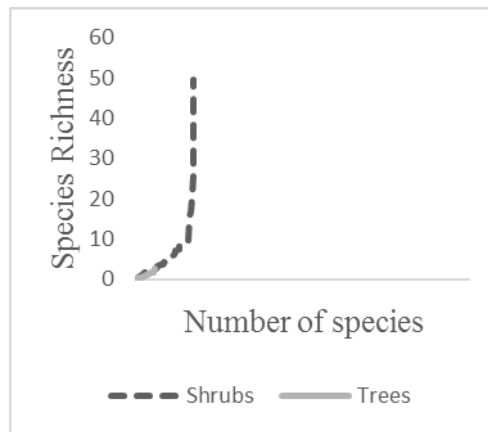


Figure 2: Species richness in undisturbed grassland

Table 3: Important Population Values for Shrub Species Undisturbed Grassland

SPECIES	R.F	R.D	R.C	IVI	S.R
<i>Solanum wightii</i> Nees	0.01	0.00	0.40	0.42	0.01
<i>Strobilanthes urceolaris</i> Gamble	0.12	0.03	0.40	0.55	0.10
<i>Crotalaria pulchra</i> Andrews	0.24	0.11	0.81	1.15	0.41
<i>Asparagus racemosus</i> Willd	0.36	0.16	0.81	1.33	0.62
<i>Nilgirianthus perrottetianus</i> (Nees) Bremek	0.48	0.21	0.81	1.50	0.82
<i>Rubus niveus</i> Thunb	1.19	0.27	0.40	1.86	1.03
<i>Pavetta blanda</i> Bremek	0.59	0.27	0.81	1.67	1.03
<i>Lonicera leschenaultia</i> Wall.	0.71	0.32	0.81	1.84	1.24
<i>Cotoneaster buxifolius</i> Wall	0.95	0.43	0.81	2.18	1.65
<i>Vernonia pectiniformis</i> DC	0.36	0.48	2.43	3.26	1.86
<i>Smilax wightii</i> A.DC	0.36	0.48	2.43	3.26	1.86
<i>Wendlandia thyrsoides</i> (Roth) Steud	1.19	0.53	0.81	2.53	2.06
<i>Strobilanthes zenkeriana</i> T.Anderson	0.83	0.56	1.21	2.60	2.17
<i>Rubus ellipticus</i> Sm	1.31	0.58	0.81	2.70	2.27
<i>Berberis leschenaultii</i> Wall. ex Wight & Arn.	1.43	0.64	0.81	2.87	2.47
<i>Rubus rugosus</i> Sm	0.95	0.64	1.21	2.80	2.47
<i>Crotalaria formosa</i> Wight & Arn.	0.95	0.64	1.21	2.80	2.47
<i>Crotalaria notonii</i> Wight & Arn	0.71	0.64	1.62	2.97	2.47
<i>Crotalaria walkeri</i> Arn	1.43	0.64	0.81	2.87	2.47
<i>Pelargonium cucullatum</i> (L.) L'Hér.	0.59	0.66	2.02	3.28	2.58
<i>Hedyotis hirsutissima</i> Bedd	1.54	0.69	0.81	3.04	2.68

<i>Prinsepia utilis</i> Royle	1.19	0.80	1.21	3.20	3.09
<i>Sophora velutina</i> Lindl	0.95	0.85	1.62	3.42	3.30
<i>Lonicera ligustrina</i> Wall.	1.31	0.88	1.21	3.40	3.40
<i>Leucas marrubioides</i> Desf	0.83	0.93	2.02	3.79	3.61
<i>Teucrium wightii</i> Hook.f	0.83	0.93	2.02	3.79	3.61
<i>Rhamnus wightii</i> Wight & Arn	2.14	0.96	0.81	3.90	3.71
<i>Moonia arnottiana</i> Wight	0.71	0.96	2.43	4.10	3.71
<i>Leucas lanceifolia</i> Desf	1.54	1.04	1.21	3.79	4.02
<i>Osbeckia leschenaultiana</i> DC.	2.38	1.06	0.81	4.25	4.12
<i>Tarenna asiatica</i> (L.) Kuntze ex K.Schum	2.38	1.06	0.81	4.25	4.12
<i>Artemisia nilagirica</i> (C.B.Clarke) Pamp	0.71	1.12	2.83	4.66	4.33
<i>Cajanus trinervius</i> (DC.) Maesen	1.31	1.17	1.62	4.09	4.54
<i>Lobelia leschenaultiana</i> (C.Presl) Skottsb	1.90	1.28	1.21	4.39	4.95
<i>Flemingia semialata</i> Roxb	1.54	1.38	1.62	4.55	5.36
<i>Gnidia glauca</i> (Fresen.) Gilg	3.21	1.43	0.81	5.45	5.57
<i>Teucrium tomentosum</i> B.Heyne ex Benth	1.31	1.46	2.02	4.79	5.67
<i>Lobelia nicotianifolia</i> Roth ex Schult	0.95	1.49	2.83	5.27	5.77
<i>Indigofera cassioides</i> DC	1.78	1.59	1.62	5.00	6.19
<i>Furcraea foetida</i> (L.) Haw	0.95	1.70	3.24	5.89	6.60
<i>Hedyotis leschenaultiana</i> DC.	2.02	1.81	1.62	5.45	7.01
<i>Desmodium ferrugineum</i> Thwaites	2.02	1.81	1.62	5.45	7.01
<i>Berberis tinctoria</i> Lesch.	2.85	1.91	1.21	5.98	7.42
<i>Hypericum mysorensense</i> F. Heyne	2.14	1.91	1.62	5.67	7.42
<i>Phoenix loureiroi</i> Kunth	2.38	2.13	1.62	6.12	8.25
<i>Dodonaea viscosa</i> (L.) Jacq	2.49	2.23	1.62	6.35	8.66
<i>Pogostemon atropurpureus</i> Benth.	1.66	2.23	2.43	6.32	8.66
<i>Sarcococca brevifolia</i> Stapf ex Gamble	1.66	2.23	2.43	6.32	8.66
<i>Osyris lanceolata</i> Hochst. & Steud	2.61	2.34	1.62	6.57	9.07
<i>Impatiens fruticosa</i> Lesch. ex DC	1.78	2.39	2.43	6.60	9.28
<i>Strobilanthes lanata</i> Nees	1.78	2.39	2.43	6.60	9.28
<i>Strobilanthes cuspidata</i> T.Anderson	2.14	2.39	2.02	6.55	9.28
<i>Teucrium fruticans</i> L.	1.78	2.39	2.43	6.60	9.28
<i>Elaeagnus conferta</i> Roxb	3.68	2.47	1.21	7.37	9.59
<i>Impatiens leschenaultii</i> Walp	2.26	4.04	3.24	9.53	15.67
<i>Pouzolzia cymosa</i> Wight	2.26	4.04	3.24	9.53	15.67
<i>Breynia retusa</i> (Dennst.) Alston	2.14	4.30	3.64	10.09	16.70
<i>Nilgiranthus wightianus</i> (Nees) Bremek	4.75	5.31	2.02	12.09	20.62
<i>Gaultheria fragrantissima</i> Wall	4.99	6.70	2.43	14.11	25.98
<i>Strobilanthes kunthianus</i> T. Anderson	7.13	12.76	3.24	23.12	49.49
Grand Total	100	100	100	300	387.97

In undisturbed grassland totally 79 trees and shrub species were found. Table 3 reveals 61shrubs (387.97 S.R), (0.04 D.I), *Strobilanthes kunthianus* has highest species richness (49.49 S.R). 8 endemic shrubaceous species were

found in undisturbed grassland they were *Solanum wightii*, *Nilgiranthus perrottetianus*, *Cotoneaster buxifolius*, *Hedyotis leschenaultiana*. *Pogostemon atropurpureus*, *Impatiens fruticosa*, *Impatiens leschenaultii*, *Nilgiranthus wightianus*.

Table 4: Important Population Values For Tree Species Undisturbed Grassland

SPECIES	R.F	R.D	R.C	IVI	S.R
<i>Symplocos microphylla</i> Wight	1.34	0.58	2.40	4.32	0.11
<i>Phyllanthus emblica</i> L.	2.55	0.56	1.20	4.31	0.11
<i>Microtropis microcarpa</i> Wight	2.43	1.06	2.40	5.89	0.21
<i>Microtropis ramiflora</i> Wight	3.65	1.59	2.40	7.64	0.31
<i>Buchanania cochinchinensis</i> (Lour.) M.R.Almeida	4.86	2.13	2.40	9.39	0.41
<i>Glochidion zeylanicum</i> (Gaertn.) A.Juss.	2.55	2.23	4.80	9.59	0.43
<i>Viburnum hebanthum</i> Wight & Arn.	3.65	2.39	3.60	9.64	0.46
<i>Glochidion ellipticum</i> Wight	2.55	3.35	7.20	13.10	0.65
<i>Symplocos obtusa</i> Wall	4.62	3.84	4.56	13.02	0.74
<i>Syzygium calophyllifolium</i> (Wight) Walp.	5.47	4.78	4.80	15.05	0.93
<i>Vaccinium neilgherrense</i> Wight	6.08	5.32	4.80	16.19	1.03
<i>Syzygium densiflorum</i> Wall. ex Wight & Arn.	5.47	5.38	5.40	16.25	1.04
<i>Symplocos cochinchinensis</i> var. <i>laurina</i> (Retz.) Noot	7.05	6.17	4.80	18.02	1.20
<i>Ilex denticulata</i> Wall. ex Wight	7.29	6.38	4.80	18.47	1.24
<i>Ligustrum robustum</i> subsp. <i>walkerii</i> (Decne.) P.S.Green	4.86	7.44	8.40	20.71	1.44
<i>Symplocos foliosa</i> Wight	7.05	7.71	6.00	20.76	1.50
<i>Vaccinium leschenaultii</i> Wight	7.29	7.97	6.00	21.27	1.55
<i>Rhododendron nilagiricum</i> Zenker	6.68	8.77	7.20	22.66	1.70
<i>Daphniphyllum neilgherrense</i> (Wight) K.Rosenthal	7.29	9.57	7.20	24.06	1.86
<i>Ilex wightiana</i> Wall. ex Wight	7.29	12.76	9.60	29.65	2.47
Grand Total	100.00	100.00	100.00	300	19.40

Table 4 reveals 18 trees (19.4 S.R), (0.07 D.I), *Ilex wightiana* has highest species richness (2.47 S.R) in trees.

- R.F – Relative Frequency
- R.D – Relative Density
- R.C – Relative Cover
- IVI – Important Value Index
- S.R -Species Richness
- D.I - Diversity Index

Figure 3: Comparison of species richness between undisturbed and disturbed grassland

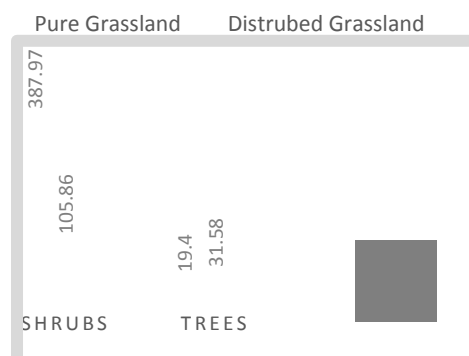


Figure 3 shows high species richness pure grassland Shrubs (387.97 S.R), Trees (105.86 S.R) 8 endemic shrub species were found they were *Solanum wightii*, *Nilgiranthus perrottetianus*, *Cotoneaster buxifolius*, *Hedyotis leschenaultiana*, *Pogostemon atropurpureus*, *Impatiens fruticosa*, *Impatiens leschenaultii*, *Nilgiranthus wightianus*. 8

endemic tree species were found they were *Symplocos microphylla*, *Microtropis microcarpa*, *Viburnum hebanthum*, *Glochidion ellipticum*, *Vaccinium neilgherrense*, *Syzygium densiflorum*, *Symplocos foliosa*, *Rhododendron nilagiricum*.

5. Discussion

The British rule familiarized the cash crops like *Eucalyptus globulus*, *Acacia mearnsii* and *Comellia sinensis* (Chandran 1997). As a result the area of the grasslands has been due to the introduction of exotic plantation and expanding of unsustainable land use practices. Native species in the grasslands have been suppressed by *Cytisus scoparius* by their busy and fast reproduction (Srinivasan et al.2012). Older grasslands have been replaced by *Acacia* plantation. These *Acacia* saplings require to be cared and tended during the first year. That means the space between the trees will be trembled upon by the plantation people and cattle which graze between the plants. These trees grow fast and will be cut down very soon for its bark and wood. The seeds of *Acacia* are very tough. But these sprout in between two to three years and grow. Allelopathic chemicals like tannin leaches out from the bark and does not allow the growth of any other native vegetation underneath. In Nilgiris plateau introduced species are pervasive everywhere. Due to lowest sunlight penetration the native plants were more in fringes than inside side of exotic plantation. Fringes are natural, the conditions are conducive to the even distribution of native plants like *Strobilanthes wightiana*, *Helichrysum buddleioides*, *Anaphalis neelgerryana*, *Anaphalis subdecurrens*, *Isodon nilgherricus*, *Rhodomyrtus tomentosa*. Broom stands are mainly responsible for displacement of dominant native plant species in the grassland (Srinivasan et al.2007). Thick mat of leaf litter of broom stand destroyed native plants by preventing sun light to their

sprouting period (Parker et al. 1997),(Wearne and Morgan 2004). It is as a mulch of the leaf litter has been placed on the grassland and native plants.

6. Conclusion

This paper covey the current status of endemic angiosperms in disturbed and undisturbed grasslands by the statistical method in ecology. Such as relative frequency, relative density, relative abundance, important value index, diversity index, species richness. The result shows the highest species richness and diversity in undisturbed grassland and most of the endemic plants disturbed by exotic weeds. So it is necessary to take step forward to stop encroachment of exotic weeds to protect grasslands for endemic species conservation to maintain the healthy ecosystem.

7. Acknowledgement

We are thankful to Government of TamilNadu Forest Department and Department of Botany, Government Arts College, Ooty for giving permission, necessary facilities during field work. We are thankful to Dr.S.Karupusamy, Assistant Professor, Department of Botany, Madura College, Madurai and Mr. R. Sivagamasundharam, Naturalist, Ooty for his support during the period of this research work.

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