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Research Article

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Microhabitat Diversity in a Lateritic Hillock of Northern Kerala, India

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Abstract

Lateritic hillocks of Kerala which are often considered as 'wastelands' in remote sensing images due to devoid of vegetation were analyzed for its floral wealth and microhabitat diversity. The study identified 9 microhabitats in the study area which supports 263 angiosperms in which majority are distributed in specific microhabitats. Floral inventory and comparison of microhabitats using Sorensen's Similarity Index indicates that each microhabitat was characterized by a specific group of species. The result showed the Shannon diversity indices ranged from 2.11 to 3.64, the Simpson index ranged from 0.0324 to 0.1515 and the Species richness index ranged from 0.0736 to 0.3369 in different microhabitats. Plants on the plateaus are adapted to various microhabitats and each of these microhabitats is unique in its edaphic properties, water availability and species composition. A detailed long-term quantitative study on the vegetation dynamics of each microhabitat is essential to understand the structure, composition and function of each microhabitat and the landscape as a whole. The baseline information generated on the vegetation and microhabitats of lateritic hills of Northern Kerala can be used to develop conservation and restoration activities on these hills which are highly threatened due to habitat degradation, fragmentation, laterite mining and change in land-use pattern.

Keywords

Lateritic hillocks; Lateritic flora; Microhabitat diversity; Kavvayi river basin; Northern Kerala

Introduction

The environment of Northern Kerala is governed by its peculiar geographic features. A unique feature of this region is the presence of lateritic hillocks which give fascinating undulations for the midland terrain in particular. Such hillocks are present up to Malappuram district towards south and they are spread to South Karnataka towards North. The lateritic hills are the most imposing but extremely threatened topographical floristic and faunistic feature of Northern Kerala. The alteration of very wet and dry condition creates an unusual ecological situation and varying microhabitats that supports unique biota. Plants on the plateaus are adapted to various microhabitats and each of these microhabitats is unique in its edaphic properties, water availability and species composition. Owing to the scarcity of woody species or forest cover the plateaus appear devoid of vegetation in remote sensing images and often considered as 'waste lands' but in reality they are landscape units having high biodiversity value and ecological significance. In monsoon, the impermeable nature of the hard rock surfaces leads to water logging and creation of ephemeral wetlands [1]. Plants species commonly seen in these areas are showing high specificity towards their microhabitat. Some species are capable of growing in very closely related microhabitats were as some are seen in two or more different microhabitats. But the species that grow in many different microhabitats having less dominance when comparing with the microhabitat specific plants. Most of the species are able to grow across a wide range of soil depths and slopes, although their dominance varies with difference in microhabitats. Regional floristic studies have reported the occurrence of many narrow-niched endemic and habitat specialist angiosperms from other lateritic plateaus [2-4] throughout the Western Ghats. The lateritic hills of Northern Kerala is also not an exception as indicated by 7 new angiosperm species reported in past couple of years by Ansari and Balakrishnan [5], Swapna et al. [6], Sunil et al. [7], Narayanan et al. [8], Sunil et al. [9] and Pradeep et al. [10]. Still, the 'wasteland' status supports the over exploitation or conversion of these important habitats for mining, monoculture plantation, industries and infrastructure development. This is happening throughout the study area and only a small portion of the lateritic hills remain un-disturbed in the study area. The management of pressures due to human impact is often misguided due to poor understanding about the special ecological features of the habitat [1]. The lateritic hillocks in the Northern Kerala are highly neglected areas from conservation point of view since they remain apparently barren for at least 7 months (November-May). Secondly, majority of the flora (90%) comprises herbaceous annuals and hence they are not considered important when compared to the woody green cover as in forest ecosystems. It has been noted that these hillocks differ completely from their surrounding vegetation in both physiognomy and floristic aspects. In spite of harsh environment, these hillocks are unique in having various micro habitat conditions and species which are habitat specific. Hence baseline scientific information regarding ecological significance of lateritic hills is needed to evolve strategies for conservation and management of this landscape especially when habitat destruction at its peak. This study is a part of collating baseline information to highlight the ecological significance of the lateritic hills of Northern Kerala, Western Ghats.

Materials and Methods

Study area

The present study was carried out in the lateritic hill of Madayipara (Figure 1) in Northern Kerala located between 12°2' North latitude and 75°16' East longitude respectively to document floral diversity and to classify and compare different microhabitats present in the hillock.

Floral inventory

A check-list of angiosperms in the study site has been prepared by visiting sites along with locality details including microhabitat. At least two field visits were made during every month for a period of one year from December 2012-November 2013. Each location was marked with GPS. Plant specimens were collected and identified

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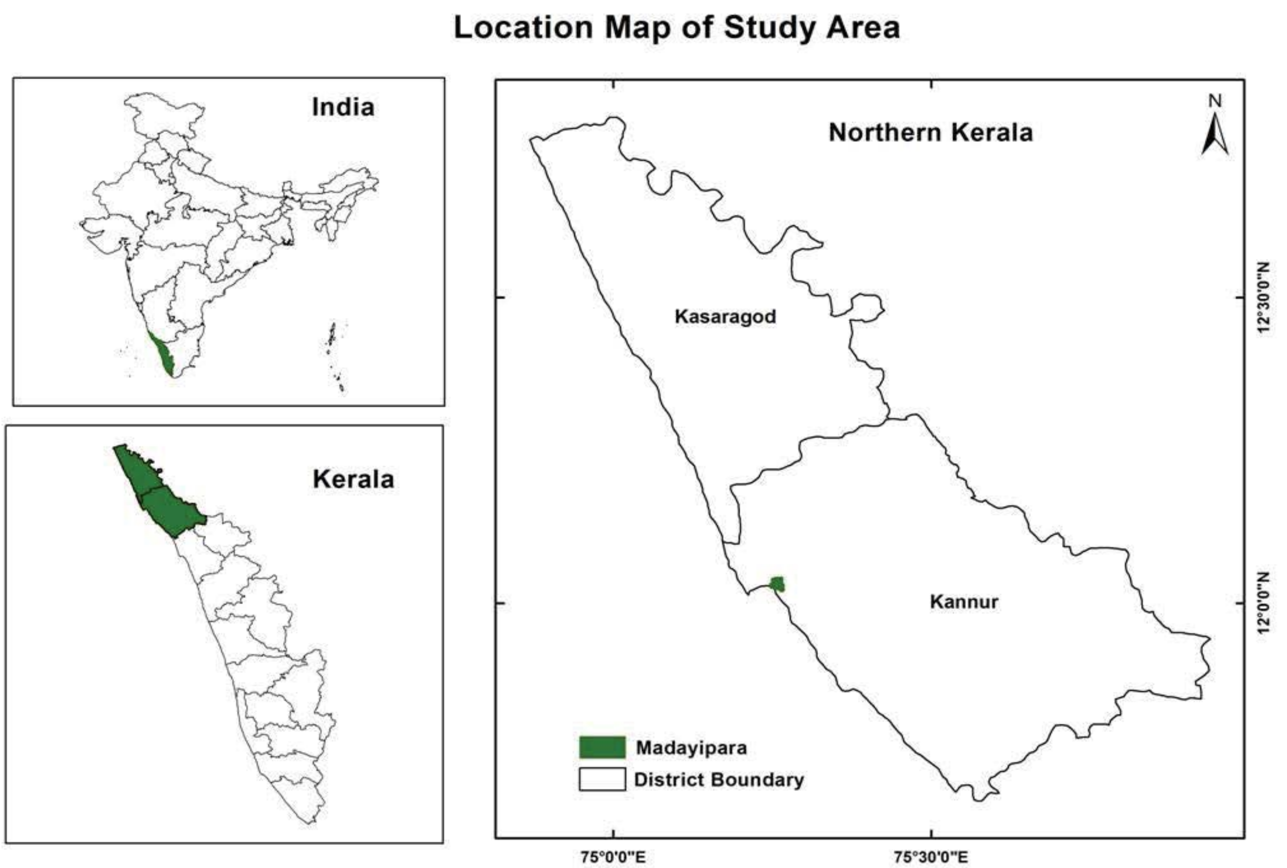

Figure 1: Study area.

using local and regional floras and deposited in KFRI herbarium.

Classification of microhabitats

The microhabitats were classified based on edaphic properties, water availability and species composition. All existing classifications attempted in other rocky plateaus of Western Ghats and other regions were referred while classifying microhabitats [11-15]. But the present classification is more site specific and does not suits exactly to any existing systems since there are factors especially species composition which are peculiar to these habitats. But the current and all the above microhabitat classifications on the rocky plateaus/hillocks are limited by the fact that there is no clear physical demarcation between the microhabitats. The microhabitats classified were further analyzed for their similarity in species composition by Sorensen's Similarity index.

In order to compare two communities we calculated the Sorensen's Similarity index is suggested by Sorensen [16].

Sorensen's Similarity index S=2C/(A+B)

Where S= Similarity index; A= number of species in sample; B= number of species in sample; C=number of species in sample common to A and B both.

Diversity index were calculated for diversity and species richness was determined by using Shannon-Wiener diversity index [17] and Menhinick's [18] species richness index as:

Species diversity index (H)=-Σ [(ni/N) log2 (ni/N)]

Where, H is Shannon –Weiner index, calculated to the base 2 of species diversity; n_i number of individual of a species i; N= total number of individual of all species in the community.

Species richness index (R)=S/ √N

Where, R= Menhinick's index of species richness; S= Number of a species in a collection; N= Number of individuals collected.

The index of dominance of the community was calculated by Simpson's index (Simpson [19])

Index of dominance (C)=Σ $[ni/N]^2$

Where, C= Simpson's index of dominance; ni=number of individuals of species i; N= total number of individuals of all species in the community.

Results and Discussions

Floral inventory

A total of 263 angiosperm species were recorded from the study area in which 62 are endemic to Western Ghats. It is interesting and noteworthy that these species were distributed in 9 microhabitats and majority of them shows very narrow ecological niche (Table 1). Four species (*Eriocaulon heterolepis, Utricularia cecilii, Eriocaulon cuspidatum and Impatiens minor*) found to be distributed in more than 5 microhabitats with a wide ecological niche as indicated by its presence in different microhabitats (Table 1).

Table 1: Species distribution pattern in different microhabitats of Lateritic hills of Northern Kerala.

No	Species Name	Microhabitats									Presence of Species*
		B	CEC	EFV	ERS	RCF	SEP	SFD	SRA	TCTA	
1	*Abrus precatorius L.*									*	1
2	*Abutilon indicum (L.) Sweet.*									*	1
3	*Acacia caesia (L.) Willd.*									*	1
4	*Acacia pennata (L.) Willd.*									*	1
5	*Acalypha indica L.*									*	1
6	*Acalypha paniculata Miq.*									*	1
7	*Acampae praemorsa (Roxb.) Blatt. & McCann.*									*	1
8	*Acanthospermum hispidum DC.*									*	1
9	*Achyranthes aspera L.*									*	1
10	*Achyranthes bidentata Blume.*									*	1
11	*Aegle marmelos (L.) Correa.*									*	1
12	*Aeschynomene americana L.*									*	1
13	*Aeschynomene aspera L.*									*	1
14	*Aganosma cymosa (Roxb.) G. Don*									*	1
15	*Ageratum conyzoides (L.) L.*									*	1
16	*Aglaia elaeagnoidea (A.Juss.) Benth.*									*	1
17	*Alangium alpinum (C.B.Clarke) W.W.Sm. & Cave.*									*	1
18	*Allamanda cathartica L.*									*	1
19	*Alloteropsis cimicina (L.) Stapf .*			*							1
20	*Alloteropsis semialata (R.Br.) Hitchc.*			*							1
21	*Alseodaphne semecarpifolia Nees.*									*	1
22	*Alstonia scholaris (L.) R. Br.*									*	1
23	*Alternanthera bettzickiana (Regel) G.Nicholson.*									*	1
24	*Alternanthera brasiliana (L.) Kuntze.*									*	1
25	*Alysicarpus bupleurifolius (L.) DC.*									*	1
26	*Amaranthus spinosus L.*									*	1
27	*Amaranthus viridis L.*									*	1
28	*Amorphophallus paeoniifolius (Dennst.) Nicolson.*									*	1
29	*Ampelocissus latifolia (Roxb.) Planch.*									*	1
30	*Anamirta cocculus (L.) Wight & Arn.*									*	1
31	*Ancistrocladus heyneanus Wall. ex J.Graham.*									*	1
32	*Anisomeles indica (L.) Kuntze.*									*	1
33	*Antidesma acidum Retz.*									*	1
34	*Antidesma bunius (L.) Spreng.*									*	1
35	*Apluda mutica L.*									*	1
36	*Apocopis mangalorensis (Hochst. ex Steud.) Henrard.*									*	1
37	*Ariopsis peltata Nimmo.*	*				*					2
38	*Aristolochia indica L.*									*	1
39	*Asystasia dalzelliana Santapau*									*	1
40	*Asystasia gangetica (L.) T.Anderson*									*	1
41	*Atlantia wightii Tanaka.*									*	1
42	*Axonopus compressus (Sw.) P.Beauv.*									*	1
43	*Azadirachta indica A.Juss.*									*	1
44	*Barleria cristata L.*									*	1
45	*Barleria prionitis L.*									*	1
46	*Begonia crenata Dryand*	*	*			*					3
47	*Begonia integrifolia Dalzell*	*									1
48	*Begonia malabarica Lam.*	*									1
49	*Begonia trichocarpa Dalzell.*	*									1
50	*Benkara malabarica (Lam.) Tirveng.*									*	1
51	*Bhidea fischeri Sreek. & B.V. Shetty.*									*	1

52	*Bidnes pilosa (Blume) Sherff.*									*	1
53	*Biophytum reinwardtii (Zucc.) Klotzsch.*			*							1
54	*Blumea membranacea DC.*									*	1
55	*Blumea oxyodonta DC.*									*	1
56	*Blyxa octandra (Roxb.) Planch. ex Thwaites.*									*	1
57	*Boerhavia diffusa L.*								*		1
58	*Bombax ceiba L.*									*	1
59	*Brachiaria reptans (L.) C.A.Gardner & C.E.Hubb.*									*	1
60	*Breynia retusa (Dennst.) Alston.*								*		1
61	*Breynia vitis-idaea (Burm.f.) C.E.C.Fisch.*									*	1
62	*Bridelia retusa (L.) A.Juss.*									*	1
63	*Bridelia stipularis (L.) Blume.*									*	1
64	*Bulbophyllum neilgherrense Wight.*									*	1
65	*Burmannia coelestis D.Don.*									*	1
66	*Butea monosperma (Lam.) Taub.*									*	1
67	*Cajanus scarabaeoides (L.) Thouars.*									*	1
68	*Callicarpa tomentosa (L.) L.*									*	1
69	*Calopogonium mucunoides Desv.*									*	1
70	*Calotropis gigantea (L.) Dryand.*									*	1
71	*Calycopteris floribunda (Roxb.) Lam. ex Poir.*									*	1
72	*Canavalia gladiata (Jacq.) DC.*									*	1
73	*Canscora diffusa (Vahl) R.Br. ex Roem. & Schult.*									*	1
74	*Canscora pauciflora Dalzell.*									*	1
75	*Cansjera rheedei J.F.Gmel.*									*	1
76	*Canthium coromandelicum (Burm.f.) Alston.*									*	1
77	*Capparis rheedei DC.*									*	1
78	*Capparis sepiaria L.*									*	1
79	*Capparis zeylanica L.*									*	1
80	*Capsicum annuum L.*									*	1
81	*Capsicum frutescens L.*									*	1
82	*Caralia brachiatia (Lour.) Merr.*									*	1
83	*Cardiospermum halicacabum L.*								*		1
84	*Careya arborea Roxb.*									*	1
85	*Cassia fistula L.*									*	1
86	*Catunaregam spinosa (Thunb.) Tirveng.*									*	1
87	*Celosia argentea L.*									*	1
88	*Cinnamomum malabatrum (Burm.f.) J.Presl.*									*	1
89	*Cissus latifolia Lam.*									*	1
90	*Cleome rutidosperma DC.*									*	1
91	*Cleome viscosa L.*									*	1
92	*Clerodendrum infortunatum L.*								*	*	2
93	*Clitoria ternatea L.*								*	*	2
94	*Commelina benghalensis L.*								*		1
95	*Commelina diffusa Burm.f.*			*	*			*	*		4
96	*Commelina erecta L.*			*	*			*	*	*	5
97	*Connarus wightii Hook.f.*								*	*	2
98	*Cosmos caudatus Kunth*								*	*	2
99	*Croton roxburghii Wall.*								*	*	2
100	*Curculigo orchioides Gaert.*								*		1
101	*Cyclea peltata (Lam.) Hook.f. & Thomson.*								*	*	2
102	*Cymbopogon citratus (DC.) Stapf.*								*	*	2
103	*Cynodon dactylon (L.) Pers.*								*	*	2
104	*Dalbergia horrida (Dennst.) Mabb.*								*	*	2
105	*Delonix regia (Hook.) Raf.*									*	1
106	*Derris scandens (Roxb.) Benth.*									*	1
107	*Desmodium gangeticum (L.) DC.*									*	1
108	*Desmodium heterophyllum (Willd.) DC.*			*							1

109	*Desmodium triflorum (L.) DC.*			*							1
110	*Dopatrium junceum (Roxb.) Buch.-Ham. ex Benth.*						*				1
111	*Drosera indica L.*			*							1
112	*Eragrostis nigra Nees ex Steud.*			*					*		2
113	*Eragrostis unioloides (Retz.) Nees ex Steud.*			*					*		2
114	*Eriocaulon cuspidatum Dalzell.*			*	*	*	*	*	*		6
115	*Eriocaulon heterolepis Steud.*		*	*	*	*	*	*	*		7
116	*Eriocaulon lanceolatum Miq. ex Körn*							*			1
117	*Eriocaulon lanceolatum Miq. ex Körn.*				*						1
118	*Eriocaulon madayiparense.*		*	*			*				3
119	*Eriocaulon parviflorum (Fyson) R.Ansari & N.P.Balakr.*				*			*			2
120	*Eriocaulon quinquangulare L.*		*	*							2
121	*Eriocaulon robustobrownianum Ruhland.*		*	*			*	*			4
122	*Eriocaulon sexangulare L.*			*			*	*	*		4
123	*Eriocaulon stellulatum Körn.*			*			*	*	*		4
124	*Eriocaulon truncatum Buch.-Ham. ex Mart.*			*			*	*			3
125	*Eriocaulon xeranthemum Mart.*			*			*	*	*		4
126	*Erycibe paniculata Roxb.*									*	1
127	*Erythrina variegata L.*									*	1
128	*Evolvulus alsinoides (L.) L.*								*		1
129	*Ficus arnottiana (Miq.) Miq.*									*	1
130	*Ficus benghalensis L.*									*	1
131	*Ficus callosa Willd.*									*	1
132	*Ficus exasperata Vahl .*									*	1
133	*Ficus religiosa L.*									*	1
134	*Flacourtia indica (Burm. f.) Merr.*								*		1
135	*Flueggea virosa (Roxb. ex Willd.) Royle .*									*	1
136	*Gloriosa superba L.*									*	1
137	*Glycosmis mauritiana (Lam.) Tanaka*									*	1
138	*Glycosmis pentaphylla (Retz.) DC.*									*	1
139	*Grewia nervosa (Lour.) Panigrahi .*									*	1
140	*Gymnema sylvestre (Retz.) Schult.*								*	*	2
141	*Habenaria longicorniculata J.Graham .*							*	*		2
142	*Habenaria periyarensis Sasidh., K.P.Rajesh & Augustine.*							*	*		2
143	*Haplanthodes nilgherrensis (Wight) R.B.Majumdar.*									*	1
144	*Heliotropium indicum L.*									*	1
145	*Heliotropium keralense Sivarajan & Manilal.*									*	1
146	*Heliotropium marifolium J.König ex Retz.*			*		*		*	*		4
147	*Hemidesmus indicus (L.) R. Br. ex Schult.*								*	*	2
148	*Hippocratea arnottiana Wight.*									*	1
149	*Holarrhena pubescens Wall.*								*		1
150	*Holigarna arnottiana Hook.f.*									*	1
151	*Hopea fastigiata (Griseb.) C.B.Clarke*									*	1
152	*Hopea ponga (Dennst.) Mabb.*									*	1
153	*Hugonia mystax Cav.*									*	1
154	*Hydnocarpus pentandrus (Buch.-Ham.) Oken.*									*	1
155	*Hyptis suaveolens (L.) Poit.*								*	*	2
156	*Ichnocarpus frutescens (L.) W.T.Aiton*								*		1
157	*Impatiens dasysperma Wight.*			*				*	*		3
158	*Impatiens diversifolia B.Heyne.*	*	*						*		3
159	*Impatiens minor (DC.) S.M. Almeida.*	*	*	*		*		*	*		6
160	*Impatiens scapiflora B.Heyne.*	*									1
161	*Ipomoea cairica (L.) Sweet.*									*	1
162	*Ipomoea hederifolia L.*									*	1

163	*Ixora brachiata* Roxb.									*	1
164	*Ixora coccinea* L.									*	1
165	*Jasminum azoricum* L.									*	1
166	*Jasminum malabaricum* Wight									*	1
167	*Jatropha curcas* L.									*	1
168	*Justicia adhatoda* L.									*	1
169	*Justicia ekakusuma* Pradeep & Sivar.									*	1
170	*Justicia japonica* Thunb.			*							1
171	*Kyllinga nemoralis* (J.R.Forst. & G.Forst.) Dandy ex Hutch. & Dalziel.					*					1
172	*Lannea coromandelica* (Houtt.) Merr.									*	1
173	*Lantana camara* L.								*	*	2
174	*Leea indica* (Burm. f.) Merr.									*	1
175	*Leea macrophylla* Roxb. ex Hornem.									*	1
176	*Lepidagathis keralensis* Madhus. & N.P.Singh .			*	*	*		*		*	5
177	*Leucas aspera* (Willd.) Link .								*	*	2
178	*Leucas biflora* (Vahl) R.Br. ex Sm.									*	1
179	*Lindernia hyssopoides* (L.) Haines.									*	1
180	*Mallotus philippensis* (Lam.) Müll.Arg.									*	1
181	*Mallotus repandus* (Willd.) Müll.Arg.									*	1
182	*Mangifera indica* L.									*	1
183	*Melastoma malabathricum* L.									*	1
184	*Memecylon randerianum* SM & MR Almeida									*	1
185	*Memecylon umbellatum* Burm. f.								*	*	2
186	*Merremia tridentata* (L.) Hallier f.									*	1
187	*Mimusops elengi* L.									*	1
188	*Mitracarpus hirtus* (L.) DC.									*	1
189	*Mollugo pentaphylla* L.									*	1
190	*Mukia maderaspatana* (L.) M.Roem.									*	1
191	*Murdannia crocea* (Griff.) Faden .				*			*			2
192	*Murdannia nudiflora* (L.) Brenan.			*							1
193	*Murdannia semiteres* (Dalzell) Santapau.			*							1
194	*Naregamia alata* Wight & Arn.							*	*		2
195	*Neanotis hohenackeri* P.Daniel & Vajr.			*	*			*	*		4
196	*Neanotis rheedei* (Wight & Arn.) W.H.Lewis.				*	*		*			3
197	*Neanotis tubulosa* (G.Don) Mabb.					*					1
198	*Neuropeltis malabarica* Ooststr.									*	1
199	*Nymphoides indica* (L.) Kuntze.						*				1
200	*Nymphoides krishnakesara* K.T.Joseph & Sivar.						*				1
201	*Oldenlandia corymbosa* L.									*	1
202	*Oldenlandia corymbosa* L.					*					1
203	*Olea dioica* Roxb.									*	1
204	*Parasopubia delphiniifolia* (L.) H.-P.Hofm. & Eb.Fisch.			*				*	*		3
205	*Paspalum conjugatum* P.J.Bergius.			*				*	*		3
206	*Paspalum scrobiculatum* L.			*				*	*		3
207	*Phyla nodiflora* (L.) Greene.									*	1
208	*Piper nigrum* L.									*	1
209	*Plumbago zeylanica* L.									*	1
210	*Pogostemon deccanensis* (Panigrahi) Press.							*	*	*	3
211	*Pogostemon quadrifolius* (Benth.) F.Muell.									*	1
212	*Polyalthia korintii* (Dunal) Benth. & Hook.f. ex Hook.f. & Thoms.								*	*	2
213	*Polycarpaea corymbosa* (L.) Lam.			*	*	*		*			4
214	*Polygala chinensis* L.			*							1
215	*Polygala elongata* Klein ex Willd.			*						*	2
216	*Pongamia pinnata* (L.) Pierre.								*	*	2
217	*Pseuderanthemum malabaricum* Gamble.								*	*	2
218	*Pterospermum diversifolium* Blume, Bijdr.								*	*	2

219	*Rotala malabarica Pradeep, K.T.Joseph & Sivar.*						*				1
220	*Rotala malampuzhensis R.V. Nair ex Cook.*						*	*	*		3
221	*Rotala rosea (Poir.) C.D.K. Cook ex H. Hara .*						*				1
222	*Samanea saman (Jacq.) Merr.*								*	*	2
223	*Santalum album L.*								*	*	2
224	*Sapindus trifoliatus L.*								*	*	2
225	*Schleichera oleosa (Lour.) Merr.*								*	*	2
226	*Scoparia dulcis L.*								*	*	2
227	*Sesamum indicum L.*								*	*	2
228	*Sesamum radiatum Schumach. & Thonn.*								*	*	2
229	*Sida acuta Burm.f.*								*	*	2
230	*Sida cordifolia L.*								*	*	2
231	*Sida rhombifolia L.*								*	*	2
232	*Smilax zeylanica L.*								*	*	2
233	*Solanum torvum Sw.*								*	*	2
234	*Stachytarpheta jamaicensis (L.) Vahl.*								*	*	2
235	*Striga angustifolia (D. Don) C.J. Saldanha.*			*				*			2
236	*Striga asiatica (L.) Kuntze*			*				*			2
237	*Striga gesnerioides (Willd.) Vatke*			*				*	*		3
238	*Strychnos nux-vomica L.*									*	1
239	*Symphorema involucratum Roxb.*									*	1
240	*Synedrella nodiflora (L.) Gaertn.*									*	1
241	*Syzygium caryophyllatum (L.) Alston.*									*	1
242	*Syzygium cumini (L.) Skeels.*									*	1
243	*Tabernaemontana alternifolia L.*									*	1
244	*Tamarindus indica L.*									*	1
245	*Tectona grandis L.f.*									*	1
246	*Terminalia bellirica (Gaertn.) Roxb.*									*	1
247	*Tinospora cordifolia (Willd.) Miers .*									*	1
248	*Trema orientalis (L.) Blume.*									*	1
249	*Trianthema portulacastrum L.*									*	1
250	*Tridax procumbens (L.) L.*									*	1
251	*Tylophora indica (Burm. f.) Merr.*									*	1
252	*Utricularia aurea Lour.*			*				*	*		3
253	*Utricularia caerulea L.*		*	*				*	*		4
254	*Utricularia cecilii P.Taylor.*	*	*	*	*		*	*	*		7
255	*Utricularia graminifolia Vahl*		*	*			*	*	*		5
256	*Utricularia reticulata Sm.*			*				*			2
257	*Utricularia striatula Sm.*			*							1
258	*Utricularia uliginosa Vahl.*			*							1
259	*Uvaria narum (Dunal) Wall. ex Hook.f. & Thoms.*									*	1
260	*Vernonia cinerea (L.) Less.*									*	1
261	*Vitex negundo L.*									*	1
262	*Wrightia tinctoria R.Br.*									*	1
263	*Ziziphus oenopolia (L.) Mill.*								*	*	2

Note: *indicates the total number of microhabitats where particular species recorded

EFV: Ephemeral flush Vegetation, ERS=Exposed rock Surfaces, RCF=Rock crevices/fissures, SEP=Small ephemeral pools, SFD=Soil-filled depressions, TCTA=Tree cover and tree associated, B=Boulders, CEC=Crust edges or cliffs, SRA=Soil-rich Areas.

Classification of microhabitats

Plants on the plateaus are adapted to various microhabitats and each of these microhabitats is unique in its edaphic properties, water availability and species composition. The most common Microhabitats types on the lateritic hillock plateaus have been described along with characteristic species assemblages (Figure 2, Table 1).

Ephemeral flush vegetation: It occurs on rocks where water seeps continuously through the rainy season and soil deposition is negligible (Figure 2a). It occupies a large area on plateaus, colonized predominantly by *Desmodium heterophyllum, Desmodium triflorum, Eriocaulon cuspidatum, Drosera indica, Utricularia graminifolia* etc. We could record 45 species in this particular microhabitat, in which 14 species specifically confined to this microhabitat (Table 1).

Exposed rock surfaces: They are flat or uneven rock surfaces, exposed to direct sunlight. They may gradually get covered by grasses during monsoon (Figure 2b). Some common plants of the habitat are. *Polycarpaea corymbosa, Lepidagathis keralensis, Eriocaulon cuspidatum, Neanotis rheedei* etc. We could record 13 species in this

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(a): Laterite hill at Madayipara

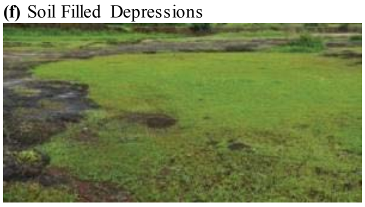
(b) Ephemeral Flush Vegetation

(c) Exposed Rock Surfaces

(d) Rock Crevices or Fissures

(e) Small Ephemeral Pools

(f) Soil Filled Depressions



(g) Soil Rich Areas

(h) Tree Cover and Tree Associates

(i) Boulders

(j) Crust Edges or Cliffs

Figure 2: The most common Microhabitats types on the lateritic hillock plateaus.

particular microhabitat in which 2 species specifically confined to this microhabitat (Table 1).

Rock crevices/fissures: They are frequently found on lateritic plateaus by providing a unique ecological niche specific to small number of species (Figure 2c). Many species such as *Begonia crenata, Heliotropium marifolium, Polycarpaea corymbosa*, *Impatiens minor*, etc. could list from this microhabitat. We could record 12 species in this particular microhabitat, in which 3 species specifically confined to this microhabitat (Table 1).

Small Ephemeral Pools (SEP): They are shallow depressions which remain filled with water during monsoon (Figure 2d). Since there is hardly any soil deposition plateau crust can be seen easily. The dominant species in this microhabitat includes *Dopatrium junceum, Rotala malabarica* and *Nymphoides krishnakesara*. We could record 16 species in this particular microhabitat in which 5 species specifically confined to this microhabitat (Table 1).

Soil-Filled Depressions (SFD): A specific microhabitat which are depressions that accumulate soil and water (Figure 2e). *Eriocaulon cuspidatum, Curculigo orchioides, Utricularia graminifolia*, etc. are the most common species found here. We could record 35 species in this particular microhabitat in which 1 species specifically confined to this microhabitat (Table 1).

Soil-Rich Areas (SRA): These are soil-rich microhabitats with more than 20 cm soil-thickness (Figure 2f). The gaps left between mats are mainly occupied by species *Commelina diffusa, Commelina erecta, Heliotropium marifolium,* etc. We could record 69 species in this particular microhabitat in which 9 species specifically confined to this microhabitat (Table 1).

Tree Cover and Tree Associated (TCTA): This microhabitat is entirely different from the rest simply because the dominance of tree species (Figure 2g). These are soil-rich areas of plateaus where tree could grow and survive. The covered shady areas provide a habitat which is entirely different from the harsh extreme environmental conditions prevailing on the exposed surfaces of plateaus. *Ficus arnottiana, Holigarna arnottiana, Hugonia mystax, Bridelia retusa, Benkara malabarica,* etc. are commonly found in this area. We could record 193 species in this particular microhabitat in which 156 species specifically confined to this microhabitat (Table 1).

Boulders (B): They are large rocks either isolated or in groups (Figure 2h). They are usually covered by lichens and bryophytes. Some typical angiosperm species also found to be associated with the systems which include *Begonia crenata, Begonia malabarica, Utricularia cecilii, Ariopsis peltata,* etc. We could record 9 species in this particular microhabitat in which 4 species specifically confined to this microhabitat (Table 1).

Crust Edges or Cliffs (CEC): They are edges of the plateaus mainly inhabited species such as *Eriocaulon cuspidatum, Begonia crenata, Ariopsis peltata,* etc. (Figure 2i). We could record 10 species in this particular microhabitat (Table 1).

When we analyzed these communities for their similarity in species composition, the index varied from 0-0.71. A total of 36 combinations were possible when 9 communities were compared between each other for their similarity in species composition, but interestingly only 2 found to have more than 50% similarity (Table 2) which clearly indicates the diversity of habitats within the lateritic hillock. On the other hand, 2 microhabitats found 100% dissimilar (Table 2). This diversity in habitats and seasonality supports unique plant community in each habitat which further supports associated faunal elements and responsible for the high species diversity of the lateritic hills. Diversity is further supported by change in species composition and community within microhabitat due to seasonal fluctuations. Barren Rock (B) and Tree cover and Tree Associates (TCTA) were found to be the two communities which show more dissimilarity with remaining seven communities. This also indicates the succession pattern in the laterite hillock in which Barren Rock (B) represents the pioneer community and Tree cover and Tree Associates (TCTA) represent the climax community. A detailed study supported by quantitative information on each community may reveal the role and level of remaining communities in the process of succession and their role in the landscape.

The Shannon diversity index (H) is ranged from 2.11 to 3.64 (Table 2). The highest Shannon diversity index was recorded in Soil Rich Areas (3.64) followed by Ephemeral Flush Vegetation (3.51), Soil Filled Depressions (3.29), Small Ephemeral Pools (2.56), Exposed Rock Surfaces (2.25), Crust Edges (2.19), and Rock Crevices (2.15) and Boulders (2.11). The Simpson index of dominance ranged from 0.0324 to 0.1515 (Table 2). The highest Simpson index was recorded in Rock Crevices (0.1515) followed by Boulders (0.1304), Exposed Rock Surfaces (0.1296), Crust Edges (0.1288), Small Ephemeral Pools (0.0951), Soil Filled Depressions (0.0489), Ephemeral Flush Vegetation (0.0380) and Soil Rich Areas (0.0324). The species richness index in different microhabitat of study area ranged from 0.0736 to 0.3369 (Table 3). The highest species richness index (R) was recorded in Soil Rich Areas (0.3369) followed by Soil Filled Depressions (0.1486), Ephemeral Flush Vegetation (0.1447), Small Ephemeral Pools (0.1016), Crust Edges (0.0862), Rock Crevices (0.0809), Boulders (0.0752) and Exposed Rock Surfaces (0.0736).

Discussion

The lateritic hillocks in Northern Kerala lack proper substrate (soil) and exhibit extreme climatic conditions. This type of environment usually share a series of stressful characteristics, such as high UV exposure, daily thermal variation, constant winds, high evapotranspiration, low water retention and impermeable soils [12]. Plant species commonly seen in the microhabitats have been described by Watve [14] and Lekhak ans Yadav [15]. The general vegetation is similar to ephemeral communities from granitic rock outcrops-Inselbergs and iron rich plateaus-in East and West Africa and Brazil [13,20,21]. Presence of *Cyanotis, Neanotis, Murdannia, Drosera, Utricularia, Lindernia, Burmannia, Fimbristylis, Rhamphicarpa* matches with that on paleotropical inselbergs described by Porembski and Brown [22] and Dörrstock et al. [23].

Table 2: Similarity index value between microhabitats in a lateritic hillock, of Northern Kerala.

	EFV	ERS	RCF	SEP	SFD	TCTA	B	CEC	SRA
EFV		0.26	0.13	0.36	0.71[a]	0.071	0.1	0.31	0.37
ERS			0.24	0.19	0.54[a]	0.073	0.09	0.17	0.14
RCF				0.12	0.39	0.055	0.26	0.25	0.07
SEP					0.043	0.045	0.074	0.42	0.25
SFD						0.025	0.011	0.26	0.47
TCTA							0[b]	0[b]	0.26
B								0.42	0.125
CEC									0.14
SRA									

Note: [a] microhabitats which having more than 50% similarity; [b] microhabitat which are 100% dissimilar

Table 3: Species Number, Shannon Diversity Index (H), Simpson Index (C) and Species Richness Index (R) of different microhabitats in a Lateritic Hillock, Northern Kerala.

Microhabitat	No. of Species	Shannon Index	Simpson Index	Species Richness Index
EFV	45	3.51	0.0380	0.1447
ERS	13	2.25	0.1296	0.0736
RCF	12	2.15	0.1515	0.0809
SEP	16	2.56	0.0951	0.1016
SFD	35	3.29	0.0489	0.1486
SRA	69	3.64	0.0324	0.3369
B	9	2.11	0.1304	0.0752
CEC	10	2.19	0.1288	0.0862

The dominance of therophytes is possibly due to their greater ability to survive under harsh environmental conditions. Due to their short life-cycle and high reproduction rate, they are well-adapted to extreme environments and high levels of disturbances. Therophytes may face high risk of mortality if rain fails or if rain is followed by a drought as these species are highly susceptible to drought without specific adaptations. Early phase of monsoon (July) was period of vegetative growth of most species and very few species started flowering in this period. Late phase of monsoon (August end and September) was a period of characteristic mass blooming mainly of non-grass families (Fabaceae, Eriocaulaceae, Rubiaceae) observed on rocky plateaus. Species richness and species diversity peaked at this period as most species of forbs and grasses completed their growth during this period. The presence of 263 species of angiosperms clearly indicates the ecological significance of lateritic hills and associated microhabitats. The conservation of these microhabitats is essential for survival and protection of these species which having specific ecological niche associated with the microhabitats of this lateritic hills. Due to its wide ecological niche, they are comparatively at lower level of risk since it could survive in varying microhabitats successfully. Further species specific quantitative studies are required to understand the population, regeneration and threat status of species especially those who are in narrow ecological niche. Seasonal fluctuations influence major changes in community structure and composition in majority of microhabitats, hence a quantitative study on the vegetation dynamics of each microhabitat along with microclimatic data is essential to understand the structure, composition, function and dynamics of the system and the landscape as a whole. Plant communities on the hillocks are continuously changing with respect to changing regimes of the climate. The growing season starts with the dominance of ephemerals and this was later replaced by perennials. Both the number of species and the number of individuals declined after a peak at the beginning of the growing season. Similar pattern is observed on the plateaus in India. The season starts with annuals which are mainly grasses and ends with perennials. Harsh environmental conditions on the lateritic hillocks have given rise to plants with certain traits that allow them to overcome environmental adversities. These traits help the plants to overcome major environmental stresses such as drought, high temperature and light intensities and nutrient deficiency.

Conclusion

Current study proved that the lateritic hills are characteristic with their diverse microhabitat and associated species diversity. The baseline information on microhabitats and floristic composition of a lateritic hill in Northern Kerala generated through this study revealed the biological and ecological significance of lateritic hills. Currently these systems are undergoing severe degradation, destruction, alteration through various activities such as mining, shifting to mono culture plantation etc. and there is no effective conservation and management activities are exists. Hence, the baseline information provided here on the biological and ecological significance of lateritic hills may further helps to develop strategies for conservation and management of this ecologically fragile system found in a human dominated landscape. Further detailed ecological and species inventory studies are required to understand the ecological process within the microhabitat and between microhabitats of lateritic hills of Northern Kerala.

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