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Pathiyil Arabhi & Maya Chandrasekharan Nair

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SEASONAL VEGETATION SHIFT AND WETLAND DYNAMICS IN VULNERABLE GRANITIC ROCKY OUTCROPS OF PALGHAT GAP OF SOUTHERN WESTERN GHATS, KERALA, INDIA

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Abstract: Low altitude granitic hillock systems prevalent in Palghat (Palakkad) Gap region of southern Western Ghats were analyzed for seasonal dynamics in wetland taxa associated with marshy ephemeral flush vegetation, small ephemeral pools and deep rock pools. Due to characteristic habitat features, such systems harbor a unique pattern of microhabitats and associated floristic components. Wet phase in rocky outcrops in the monsoon season establishes a hydro-geomorphic habitat that supports establishment of wetland taxa like *Eriocaulon*, *Drosera*, *Utricularia*, *Dopatrium*, and *Rotala*. Seasonal shift in the floral associations was evident in tune with wetland dynamics. Wet rocks support ephemeral flush vegetation which display some unique plant associations of species of *Eriocaulon*, *Utricularia*, *Drosera*, *Cyanotis*, *Murdannia*, and *Lindernia*. Small ephemeral pools displayed taxa like *Rotala malampuzhensis* R.V. Nair, *Dopatrium junceum* (Roxb.) Buch.-Ham. ex Benth., *D. nudicaule* (Willd.) Benth., *Monochoria vaginalis* (Burm.f.) C. Presl, and *Cyperus iria* L. Rocky pools are the habitats of aquatic angiosperms like *Nymphaea nouchali* Burm. f., *Ludwigia adscendens* (L.) H. Hara, *Utricularia aurea* Lour. and *Hydrilla verticillata* (L.f.) Royle. The study documented 121 plant taxa from 37 families during a wet phase from rocky outcrops of the study area. Gradual shift in vegetation is evident as water recedes from granitic hillocks. During the period from December to March, the rocky pools dry up which results in a shift in the vegetation pattern where Poaceae members form the dominant elements. As most of the rocky outcrops are exposed to extreme temperature and acute water shortage, the taxa inhabiting such ecosystems tend to evolve much faster than in other habitats. Moreover, the vicinity of these hillocks in the Palghat Gap region to human settlements, face threats like fire, grazing, quarrying, dumping of wastes etc. which may cause considerable loss to the very sensitive plant communities which are not yet fully documented.

Keywords: Granitic hillocks, Palakkad, vegetation shift, wetland dynamics.

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INTRODUCTION

Rocky outcrops, which rise abruptly from the surrounding landscape, have a patchy distribution, and represent centers of diversity and endemism for both animal and plant life (Hopper & Withers 1997). They support high levels of species diversity and endemism, have provided stable micro-climates for thousands of years and also provide important insights into our ecological past where they contain the remains of extinct species (Fitzsimons & Michael 2017). They exhibit extreme climatic and edaphic features strikingly different from the surrounding environment.

The Palghat Gap, a 32-km break in the hill ranges of the Western Ghats with an average elevation of 140m, is a peculiar geological feature in southern India along 10.750°N latitude which divides the Western Ghats into Nilgiri Hills on the northern lip and Anamalai-Palani Hills on the southern lip. The gap area is characterized with gneissic, charnockite and amphibolite rock types (Cruz et al. 2000). Small and medium-sized rocky hillocks are common in the Gap area and most of them are covered with rich vegetation providing rich grazing areas for cattle. They perform significant ecosystem services, as the main repositories of water resources keeping the wells of nearby areas filled. In Kerala, lateritic and granitic hillocks occur with a prevalence of lateritic ones in northern and granitic hillocks in southern Kerala. Numerous low-altitude hillock systems which are characteristic to the Palghat Gap region of southern Western Ghats have their own unique manifestations of floral elements due to spatial and ecological isolation from the surrounding vegetation. These granitic outcrops provide suitable microhabitats for many rare and endemic plants. Floristic explorations on such low-altitude hillocks resulted in the discoveries of taxa new to science (Jose et al. 2013, 2015).

Low-altitude hillock systems exhibit seasonal wetland dynamics and periodical shifts in vegetation patterns in response to the onset and retreat of the monsoons. The wet phase in such hillock systems is characterized by unique associations of ephemeral herbaceous floral elements in specific microhabitats like seasonal pools (Pramod et al. 2014). Most of the hillocks in the Palghat Gap region are found in the neighborhood of human settlements and are facing various threats, including fire, grazing, quarrying and dumping of wastes, which cause considerable loss to the very sensitive plant communities which are not yet fully documented. With this background, the present paper summarizes the floristic diversity of ephemerals associated with the

microhabitats of granitic hillocks in the Palghat Gap of southern Western Ghats.

MATERIALS AND METHODS

Study Area

Documentation of wetland taxa in selected granitic hillocks of seven different forest ranges, viz., Alathur, Kollengode, Nelliampathy, Olavakkode, Ottappalam, Walayar, and Mannarkkad was carried out between June 2016 and May 2018. The sampling locations lie between 10.551–11.010 °N and 76.161–76.828 °E (Image 1). The plants were collected and identified using regional floras along with reference to local herbaria MH and CALI and enumerated based on APG IV (Chase et al. 2016). The nomenclature validation was carried out using IPNI (www.ipni.org), The Plant List (www.theplantlist.org) databases and Flowering Plants of Kerala (Sasidharan 2014). The plant diversity in different microhabitats during the wet phase were identified (Sreejith et al. 2016), documented and seasonal vegetation shift was observed. The threat assessment of the taxa was based on IUCN (2019) guidelines. The plants and habitats were photographed using digital cameras Nikon D 3200 and Sony Cyber shot DSC HX7V.

RESULTS AND DISCUSSION

Granitic hillock systems harbor unique microhabitats and associated floristic components. Seasonal shift in vegetation was apparent, which shows demarcating wet and dry phases based on the availability of moisture. The micro environment on the rock surface in these hillock systems varied between extremely hot and arid in dry seasons to water logged and slippery in the wet season. Microhabitat conditions present on the outcrops vary significantly from the adjoining areas and hence they can be referred to as terrestrial habitat islands.

Wet phase in granitic hillocks

The establishment of the wet phase in the rocky outcrops begins with the onset of the southwest monsoon and ends with the completion of the northeast monsoon. Occurrence of the wet phase in rocky outcrops in the form of different microhabitats in the monsoon season (June–November) establishes hydro-geomorphic habitats with significant microhabitats and floral associations (Image 2).

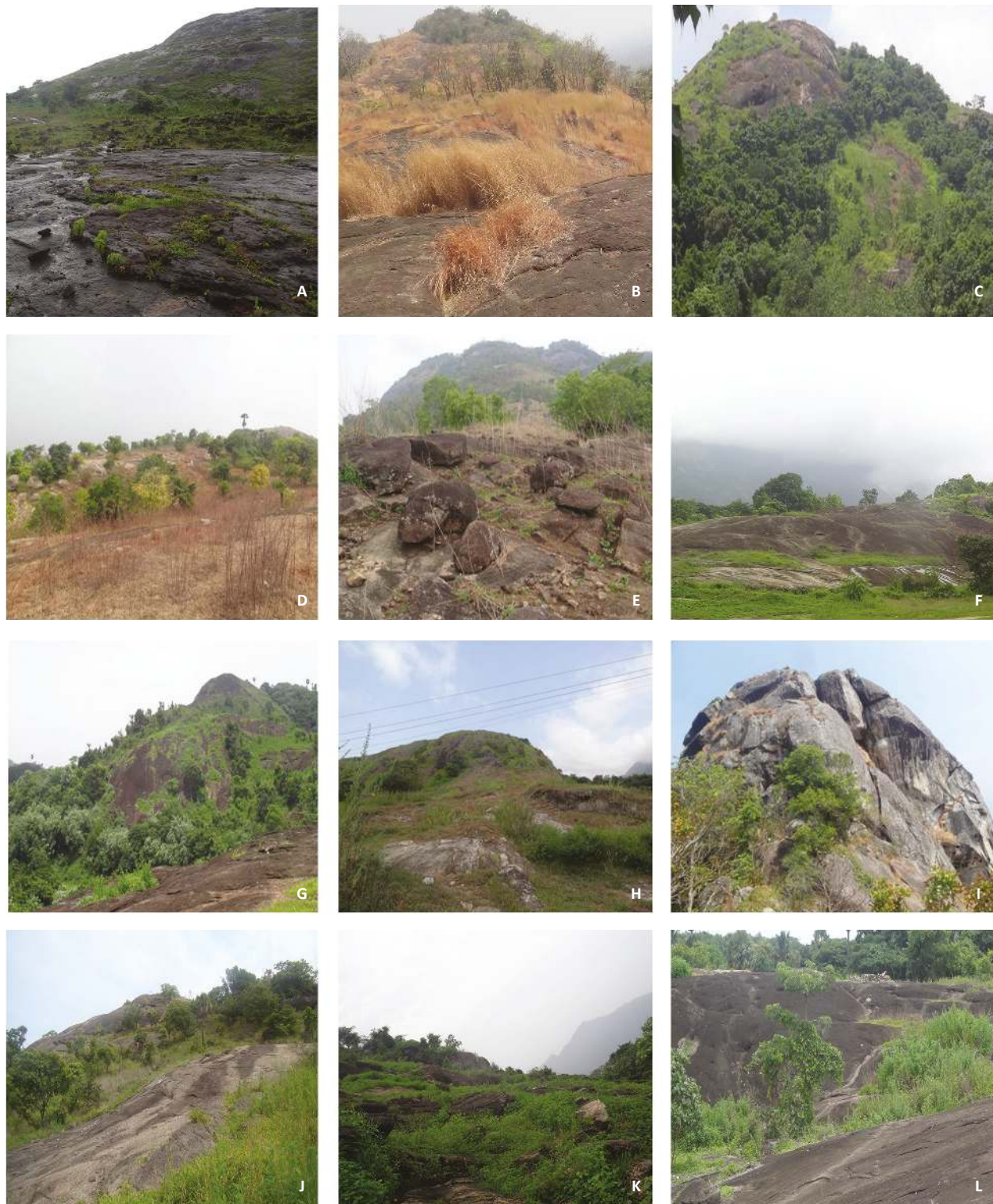


Image 1. Study area and sample hillocks: A—Wet phase in hillocks | B—Dry phase in hillocks | C—Vizhumala | D—Karadikunnu | E—Ayilamudichi mala | F—Mambram | G—Anangan mala | H—Koomachi mala | I—Vakkodan mala | J—Vamala | K—Athanad | L—Mallanpara. © Pathiyil Arabhi.

a) Ephemeral flush vegetation (EFV): This is the predominant vegetation type occurring in the microhabitats of granitic hillocks during the wet phase.

The ephemeral herbaceous plants flourish in the open rocky slopes through which water flows slowly. This microhabitat harbors 11 species, viz., *Burmannia*

coelestis D. Don, *Cyanotis papilionacea* (Burm. f.) Schult. & Schult. f., *Drosera indica* L., *D. burmanni* Vahl, *Eriocaulon pectinatum* Ruhland, *E. thwaitesii* Körn., *E. xeranthemum* Mart., *Lindernia ciliata* (Colsm.) Pennell, *Murdannia semiteres* (Dalzell) Santapau, *Utricularia lazulina* P. Taylor, and *U. graminifolia* Vahl; and of these, species of *Utricularia* are exclusive EFV endemics and the insectivorous taxa which prefer nutrient deficient soil, viz., *Drosera* spp. and *Utricularia* spp., were found to be well adapted to this habitat. This micro-eco-climate showed unique plant associations between *Eriocaulon-Utricularia-Drosera* and *Lindernia*.

b) Small ephemeral pools (SEP): Most of the rocky outcrops possess several shallow depressions which remain filled with water during the rainy season. They form unique microhabitats for some wet phase elements, such as, *Dopatrium junceum* (Roxb.) Buch.-Ham. ex Benth., *D. nudicaule* (Willd.) Benth., *Rotala indica* (Willd.) Koehne, *R. malampuzhensis* R. V. Nair, *Monochoria vaginalis* (Burm. f.) C. Presl, and *Cyperus iria* L. The study recorded 20 species (Table 1) from this microhabitat and the above six taxa were specifically confined to this microhabitat.

c) Rock pools (RP): Some hillocks possess deep water-filled pools mainly created as a result of quarrying which harbor aquatic taxa like *Nymphaea nouchali* Burm.f., *Hydrilla verticillata* (L.f.) Royle, *Ludwigia adscendens* (L.) H. Hara, *Utricularia aurea* Lour., *Ipomoea aquatica* Forssk., *Marsilea quadrifolia* L., and *Rotala mexicana* Schltdl. & Cham. This unique ecosystem recorded eight species, of which the first four members were recorded from this microhabitat only.

d) Exposed rock surfaces (ERS): These are flat or irregular rocky surfaces which were directly exposed to sunlight. These areas with poor soil deposition remain more or less wet during the rainy season. This survey recorded 35 taxa from this microhabitat, viz., *Burmanna coelestis* D. Don, *Centranthera indica* (L.) Gamble, *Geissaspis cristata* Wight & Arn., and *Lobelia alsinoides* Lam., of which *Xyris pauciflora* Willd. was recorded specifically from this microhabitat.

e) Rocky crevices and fissures (RCF): Granitic outcrops possess several rock crevices and fissures with very thin soil deposition which act as ecological niche for some specific species like *Henckelia incana* (Vahl) Spreng. and *Cyanotis arachnoidea* C.B. Clarke, and about 14 species were recorded from this microhabitat and the above mentioned taxa were specifically confined to this habitat.

f) Soil-filled depressions (SFD): Rocky outcrops possess several depressions which accumulate water

and soil during the rainy season and provide a marshy habitat. Around 81 species were recorded from this particular microhabitat of which *Alysicarpus monilifer* (L.) DC., *Isoetes coromandeliana* L.f., *Crotalaria linifolia* L.f., *Cyanotis burmanniana* Wight, *Ophioglossum nudicaule* L.f., *Lindernia anagallis* (Burm.f.) Pennell, *Ludwigia hyssopifolia* (G. Don) Exell, *Mitrasacme pygmaea* R.Br., etc. were some species found exclusively in this microhabitat.

g) Soil rich area (SRA): These microhabitats with good soil deposition having more than 20cm soil thickness, during the wet phase were frequently occupied by species like *Chrysopogon aciculatus* (Retz.) Trin, *Cyanotis cristata* (L.) D. Don, *Eclipta prostrata* (L.) L., *Spermacoce articularis* L.f., *Spermacoce hispida* L., *Spermacoce alata* Aubl., *Commelina clavata* C.B. Clarke, *Commelina diffusa* Burm.f., *Eragrostis unioides* (Retz.) Nees ex Steud., and *Spermacoce ocymoides* Burm.f. Among them, the first six taxa were exclusively found in this microhabitat.

h) Boulders (B): These microhabitats consist of isolated rocks or large rocks in groups which were found to be inhabited with some mosses, pteridophytes like *Cheilanthes opposita* Kaulf., *Parahemionitis cordata* (Hook. & Grev.) Fraser-Jenk. and angiosperms like *Bulbostylis barbata* (Rottb.) C.B. Clarke, *Osbeckia muralis* Naudin, and *Oxalis corniculata* L. during the wet phase.

During the study 121 plant species belonging to 37 families (Table 1) were documented from different microhabitats in the wet phase (June–November). The most represented family were Fabaceae with 22 species followed by Cyperaceae with 16 species and Commelinaceae with 10 species.

Dry phase in granitic hillocks

A gradual shift in vegetation was evident as water receded from granitic hillocks after the retreat of the monsoon. During the period from December to April, the small ephemeral pools dry up, ephemeral flush vegetation disappears, water level in deep rock pools lowers, which results in a shift in wet vegetation to a drought-adaptive taxa. Dry phase is characterized by the complete absence of microhabitats like EFV and SEP and shift in plant associations in other microhabitats like ERS, RCF, SFD and SRA (Image 3).

During the dry phase, plant species like *Heliotropium marifolium* J. Koenig ex Retz. and *Cleome aspera* J. Koenig ex DC. dominate in exposed rock surfaces (ERS) and rock crevices and fissures (RCF) harbors plant taxa like *Anisochilus carnosus* (L.f.) Wall., *Andrographis echioides* (L.) Nees, *Cleome viscosa* L., *Dimeria deccanensis* Bor,



Image 2. Wetphase microhabitats in rocky hillocks: A–C—Ephemeral flush vegetation (A—*Cyanotis papilionacea* (Burm.f.) Schult. & Schult.f.; B—*Eriocaulon pectinatum* Ruhland; C—*Utricularia lazulina* P. Taylor) | D—Rock pools | E&F—Small ephemeral pools | G—Exposed rock surfaces (*Sesamum prostratum* Retz.) | H—Soil filled depressions (*Cyperus* spp.) | I&J—Rocky crevices and fissures (I—*Cyperus maderaspatanus* Willd.; J—*Cyanotis papilionacea* (Burm.f.) Schult. & Schult.f.) | K—Soil rich area | L—Boulders. © Pathiyil Arabhi.

Hyptis suaveolens (L.) Poit., and *Theriophonum fischeri* Sivad. Plant species like *Perotis indica* (L.) Kuntze, *Croton hirtus* L'Hér., *Ischaemum rugosum* Salisb.,

Rhynchosia rufescens (Willd.) DC., *Blumea virens* DC., *Richardia scabra* L., *Tephrosia villosa* (L.) Pers., *Merremia tridentata* (L.) Hallier f., and *Apluda mutica* L. were

Table 1. Distribution of wet phase floristic elements in different microhabitats.

	Botanical name	Family	Micro-habitats
1	<i>Aeschynomene indica</i> L.	Fabaceae	SEP, SFD
2	<i>Alysicarpus bupleurifolius</i> (L.) DC.	Fabaceae	SFD
3	<i>Alysicarpus heterophyllus</i> (Baker) Jafri & Ali	Fabaceae	SFD
4	<i>Alysicarpus monilifer</i> (L.) DC.	Fabaceae	SFD
5	<i>Alysicarpus vaginalis</i> (L.) DC.	Fabaceae	ERS, SFD
6	<i>Bulbostylis barbata</i> (Rottb.) C.B.Clarke	Cyperaceae	B, ERS, RCF
7	<i>Bulbostylis puberula</i> Kunth	Cyperaceae	SEP, RCF
8	<i>Burmanna coelestis</i> D.Don	Burmanniaceae	ERS, EFV
9	<i>Centranthera indica</i> (L.) Gamble	Orobanchaceae	ERS, SFD
10	<i>Centranthera tranquebarica</i> (Spreng.) Merr.	Orobanchaceae	SEP, SFD
11	<i>Chamaecrista absus</i> (L.) H.S.Irwin & Barneby	Fabaceae	SFD, SRA
12	<i>Chamaecrista kleinii</i> (Wight & Arn.) V.Singh	Fabaceae	SFD
13	<i>Chamaecrista mimosoides</i> (L.) Greene	Fabaceae	ERS, SFD
14	<i>Chamaecrista nictitans</i> subsp. <i>patellaria</i> (Collad.) H.S.Irwin & Barneby	Fabaceae	ERS, SFD
15	<i>Cheilanthes opposita</i> Kaulf.	Pteridaceae	B
16	<i>Chrysopogon aciculatus</i> (Retz.) Trin.	Poaceae	SRA
17	<i>Commelina clavata</i> C.B.Clarke	Commelinaceae	SFD, SRA
18	<i>Commelina diffusa</i> Burm.f.	Commelinaceae	SFD, SRA
19	<i>Commelina wightii</i> Raizada	Commelinaceae	ERS, SFD
20	<i>Crotalaria linifolia</i> L.f.	Fabaceae	SFD
21	<i>Crotalaria nana</i> Burm.f.	Fabaceae	SFD
22	<i>Cyanotis arachnoidea</i> C.B.Clarke	Commelinaceae	RCF
23	<i>Cyanotis axillaris</i> (L.) D.Don ex Sweet	Commelinaceae	ERS, SEP
24	<i>Cyanotis burmanniana</i> Wight	Commelinaceae	SFD
25	<i>Cyanotis cristata</i> (L.) D.Don	Commelinaceae	SRA
26	<i>Cyanotis papilionacea</i> (Burm.f.) Schult. & Schult.f.	Commelinaceae	EFV, ERS, RCF
27	<i>Cyperus clarkei</i> T.Cooke	Cyperaceae	SFD
28	<i>Cyperus compressus</i> L.	Cyperaceae	SFD
29	<i>Cyperus cyperinus</i> (Retz.) Suringar	Cyperaceae	SFD
30	<i>Cyperus dubius</i> Rottb.	Cyperaceae	SFD
31	<i>Cyperus iria</i> L.	Cyperaceae	SEP
32	<i>Cyperus maderaspatanus</i> Willd.	Cyperaceae	ERS, RCF
33	<i>Cyperus rotundus</i> L.	Cyperaceae	SFD
34	<i>Desmodium triflorum</i> (L.) DC.	Fabaceae	ERS, SFD
35	<i>Dipcadi montanum</i> (Dalzell) Baker	Asparagaceae	SFD
36	<i>Dopatrium junceum</i> (Roxb.) Buch.-Ham. ex Benth.	Plantaginaceae	SEP
37	<i>Dopatrium nudicaule</i> (Willd.) Benth.	Plantaginaceae	SEP
38	<i>Drosera burmanni</i> Vahl	Droseraceae	ERS, EFV
39	<i>Drosera indica</i> L.	Droseraceae	ERS, EFV
40	<i>Eclipta prostrata</i> (L.) L.	Asteraceae	SRA
41	<i>Eragrostis unioides</i> (Retz.) Nees ex Steud.	Poaceae	ERS, SFD, SRA
42	<i>Eriocaulon pectinatum</i> Ruhland	Eriocaulaceae	EFV, ERS
43	<i>Eriocaulon thwaitesii</i> Körn.	Eriocaulaceae	EFV, ERS
44	<i>Eriocaulon xeranthemum</i> Mart.	Eriocaulaceae	EFV, ERS
45	<i>Fimbristylis aestivalis</i> Vahl	Cyperaceae	RCF, SFD
46	<i>Fimbristylis argentea</i> (Rottb.) Vahl	Cyperaceae	SFD
47	<i>Fimbristylis falcata</i> (Vahl) Kunth	Cyperaceae	SFD
48	<i>Fimbristylis littoralis</i> Gaudich.	Cyperaceae	SFD
49	<i>Fimbristylis microcarya</i> F.Muell.	Cyperaceae	SFD, SEP
50	<i>Fimbristylis polytrichoides</i> (Retz.) Vahl	Cyperaceae	RCF, SFD
51	<i>Fimbristylis schoenoides</i> (Retz.) Vahl	Cyperaceae	SEP, SFD
52	<i>Geissaspis cristata</i> Wight & Arn.	Fabaceae	ERS, SFD
53	<i>Geissaspis tenella</i> Benth.	Fabaceae	ERS, SFD
54	<i>Glinus oppositifolius</i> (L.) Aug. DC.	Molluginaceae	SFD
55	<i>Henckelia incana</i> (Vahl) Spreng.	Gesneriaceae	RCF
56	<i>Hoppea fastigiata</i> (Griseb.) C.B.Clarke	Gentianaceae	ERS, SFD
57	<i>Hydrilla verticillata</i> (L.f.) Royle	Hydrocharitaceae	RP
58	<i>Hygrophila ringens</i> (L.) R.Br. ex Spreng.	Acanthaceae	SFD
59	<i>Indigofera uniflora</i> Roxb.	Fabaceae	ERS, SFD
60	<i>Ipomoea aquatica</i> Forssk.	Convolvulaceae	SEP, RP
61	<i>Ipomoea marginata</i> (Desr.) Verdc.	Convolvulaceae	SFD, SEP
62	<i>Isoetes coromandeliana</i> L.f.	Isoetaceae	SFD
63	<i>Limnophila aromatica</i> (Lam.) Merr.	Plantaginaceae	SEP, SFD
64	<i>Limnophila heterophylla</i> (Roxb.) Benth.	Plantaginaceae	SEP, SFD
65	<i>Lindernia anagallis</i> (Burm.f.) Pennell	Linderniaceae	SFD
66	<i>Lindernia antipoda</i> (L.) Alston	Linderniaceae	SFD
67	<i>Lindernia caespitosa</i> (Blume) Panigrahi	Linderniaceae	SFD
68	<i>Lindernia ciliata</i> (Colsm.) Pennell	Linderniaceae	EFV, ERS, SFD
69	<i>Lindernia crustacea</i> (L.) F.Muell.	Linderniaceae	SFD
70	<i>Lindernia hyssopioides</i> (L.) Haines	Linderniaceae	SFD
71	<i>Lindernia nummulariifolia</i> (D.Don) Wettst.	Linderniaceae	SFD, SEP
72	<i>Lindernia rotundifolia</i> (L.) Alston	Linderniaceae	SFD, SEP
73	<i>Lobelia alsinoides</i> Lam.	Campanulaceae	ERS, SFD
74	<i>Ludwigia adscendens</i> (L.) H.Hara	Onagraceae	RP

	Botanical name	Family	Micro-habitats
75	<i>Ludwigia hyssopifolia</i> (G.Don) Exell	Onagraceae	SFD
76	<i>Marsilea quadrifolia</i> L.	Marsileaceae	SEP, RP
77	<i>Melochia corchorifolia</i> L.	Malvaceae	SFD, SRA
78	<i>Microcarpaea minima</i> (K.D.Koenig ex Retz.) Merr.	Plantaginaceae	SFD
79	<i>Mitrasacme indica</i> Wight	Loganiaceae	SFD
80	<i>Mitrasacme pygmaea</i> R.Br.	Loganiaceae	SFD
81	<i>Monochoria vaginalis</i> (Burm.f.) C.Presl	Pontederiaceae	SEP
82	<i>Murdannia semiteres</i> (Dalzell) Santapau	Commelinaceae	EFV, ERS
83	<i>Murdannia spirata</i> (L.) G.Brückn.	Commelinaceae	SFD
84	<i>Nymphaea nouchali</i> Burm.f.	Nymphaeaceae	RP
85	<i>Oldenlandia corymbosa</i> L.	Rubiaceae	SFD, RCF
86	<i>Oldenlandia diffusa</i> (Willd.) Roxb.	Rubiaceae	SFD
87	<i>Oldenlandia dineshii</i> Sojan & Suresh	Rubiaceae	ERS, SFD
88	<i>Ophioglossum nudicaule</i> L.f.	Ophioglossaceae	SFD
89	<i>Oryza rufipogon</i> Griff.	Poaceae	SFD
90	<i>Osbeckia muralis</i> Naudin	Melastomataceae	B, ERS, RCF, SFD
91	<i>Oxalis corniculata</i> L.	Oxalidaceae	B, SFD
92	<i>Pandanus canaranus</i> Warb.	Pandanaceae	RP
93	<i>Parahemionitis cordata</i> (Hook. & Grev.) Fraser-Jenk.	Pteridaceae	B
94	<i>Parasopubia delphinifolia</i> (L.) H.-P.Hofm. & Eb.Fisch.	Orobanchaceae	ERS, SFD
95	<i>Polygala chinensis</i> L.	Polygalaceae	SFD
96	<i>Polygala persicariifolia</i> DC.	Polygalaceae	ERS, RCF
97	<i>Rhamphicarpa fistulosa</i> (Hochst.) Benth.	Orobanchaceae	ERS, SFD

	Botanical name	Family	Micro-habitats
98	<i>Rhynchosia rufescens</i> (Willd.) DC.	Fabaceae	RCF, SFD
99	<i>Rhynchosia suaveolens</i> (L.f.) DC.	Fabaceae	RCF, SFD
100	<i>Rotala indica</i> (Willd.) Koehne	Lythraceae	SEP
101	<i>Rotala malampuzhensis</i> R.VNair	Lythraceae	SEP
102	<i>Rotala mexicana</i> Schlttdl. & Cham.	Lythraceae	SEP, RP
103	<i>Sesamum prostratum</i> Retz.	Pedaliaceae	ERS, SFD
104	<i>Setaria pumila</i> (Poir.) Roem. & Schult.	Poaceae	SFD, SRA
105	<i>Sida acuta</i> Burm.f.	Malvaceae	SFD, SRA
106	<i>Smithia blanda</i> Wall.	Fabaceae	SFD
107	<i>Smithia conferta</i> Sm.	Fabaceae	SFD
108	<i>Spermocoe alata</i> Aubl.	Rubiaceae	SRA
109	<i>Spermocoe articularis</i> L.f.	Rubiaceae	SRA
110	<i>Spermocoe hispida</i> L.	Rubiaceae	SRA
111	<i>Spermocoe ocymoides</i> Burm.f.	Rubiaceae	SFD, SRA
112	<i>Spermocoe pusilla</i> Wall.	Rubiaceae	RCF, SFD
113	<i>Striga angustifolia</i> (D.Don) C.J. Saldanha	Orobanchaceae	ERS, SFD
114	<i>Striga asiatica</i> (L.) Kuntze	Orobanchaceae	ERS, SFD
115	<i>Tephrosia maxima</i> (L.) Pers.	Fabaceae	SFD, SRA
116	<i>Tephrosia purpurea</i> (L.) Pers.	Fabaceae	ERS, SFD, SRA
117	<i>Utricularia aurea</i> Lour.	Lentibulariaceae	RP
118	<i>Utricularia lazulina</i> P.Taylor	Lentibulariaceae	EFV
119	<i>Utricularia graminifolia</i> Vahl	Lentibulariaceae	EFV
120	<i>Xyris pauciflora</i> Willd.	Xyridaceae	ERS
121	<i>Zornia gibbosa</i> Span.	Fabaceae	ERS, SFD

EFV—Ephemeral flush vegetation | SEP—Small ephemeral pool | RP—Rock pool | ERS—Exposed rock surface | RCF—Rocky crevice and fissure | SFD—Soil-filled depression | SRA—Soil rich area | B—Boulder.

mostly seen in soil-filled depressions (SFD) during the dry phase. Soil rich area (SRA) is dominated by plant taxa such as *Alternanthera bettzickiana* (Regel) G. Nicholson, *Achyranthes aspera* L., *Acalypha alnifolia* Klein ex Willd., *Sesamum radiatum* Schumach. & Thonn., *Sida cordata* (Burm.f.) Borss. Waalk., *Boerhavia diffusa* L., *Ipomoea pes-tigridis* L., grasses like *Heteropogon contortus* (L.) P. Beauv. ex Roem. & Schult., *Arundinella mesophylla* Nees ex Steud., and *Garnotia tenella* (Arn. ex Miq.) Janowski during the dry phase. During the dry phase, the mosses and pteridophytes inhabited on boulders (B) dry up.

Both dry and wet phases in granitic outcrops share floristic elements of scrub jungles and tree cover and such vegetation provides isolated patches of greenery to these vulnerable habitats.

Scrub jungle elements

Some shrubs and climbers give a stunted forest appearance to the rocky hillocks. *Ziziphus jujuba* Mill., *Z. oenopolia* (L.) Mill., *Canthium coromandelicum* (Burm.f.) Alston, *C. rheedei* DC., *Euphorbia trigona* Mill., *Flacourtia indica* (Burm.f.) Merr., *Ehretia microphylla* Lam., *Catunaregam spinosa* (Thunb.) Tirveng., *Casearia esculenta* Roxb., *C. wynadensis* Bedd., *Abrus precatorius* L., *Getonia floribunda* Roxb., *Pterolobium hexapetalum* (Roth) Santapau & Wagh, and *Spatholobus parviflorus* (DC.) Kuntze. are some of the common scrub jungle elements found in rocky systems.

Tree cover

The extent of tree cover varies in different hillock systems from thick tree cover and associated shade loving shrub elements to hillock systems with sparsely



Image 3. Dryphase microhabitats in rocky hillocks: A—Exposed rock surfaces (*Heliotropium marifolium* J. Koenig ex Retz.) | B&C—Rocky crevices and fissures (B—*Anisochilus carnosus* (L.f.) Wall.; C—*Theridaphnum fischeri* Sivad.) | D—Soil filled depressions | E—Soil rich area | F&G—Tree cover | H—Scrub jungle elements (*Ziziphus oenopolia* (L.) Mill.). © Pathiyil Arabhi.

distributed tree species. This study documented 100 tree taxa from rocky hillocks and among them, *Cochlospermum religiosum* (L.) Alston, *Givotia moluccana* (L.) Sreem., *Firmiana simplex* (L.) W. Wight, *Phyllanthus emblica* L., *Strychnos nux-vomica* L., *S. potatorum* L.f., *Morinda pubescens* Sm., *Azadirachta indica* A. Juss., *Holarrhena pubescens* Wall. ex G. Don, *Cleistanthus collinus* (Roxb.) Benth. ex Hook.f., *Wrightia tinctoria* R.Br., *Ficus exasperata* Vahl, *Pterocarpus marsupium* Roxb., and *Terminalia paniculata* Roth. were

common inhabitants of most of the rocky hillocks.

Threatened Taxa with conservation significance

The vulnerable habitats of granitic rocky outcrops of the Palghat Gap of the southern Western Ghats harbor taxa with conservation significance. The analysis revealed the presence of five taxa under threatened category (IUCN 2019). *Pterocarpus marsupium* Roxb. among tree cover element is classified as Near Threatened and *Cleistanthus collinus* (Roxb.) Benth. ex Hook.f. and

Santalum album L. are Vulnerable. The wet phase taxon, *Eriocaulon pectinatum* Ruhland and scrub jungle element, *Casearia wynadensis* Bedd. are also classified as Vulnerable as per IUCN Red List of Threatened Plants version 2019-2 (IUCN 2019). Conservation status of about 45% wetland taxa recorded from the study area are not yet assessed and as the habitats of these elements are facing serious threats, the future of these taxa inhabiting these niche is uncertain.

Threats to low altitude hillocks in Palghat Gap region

Rapid urbanization places anthropogenic pressures on low altitude granitic hillocks in the Gap region of the southern Western Ghats. Indiscriminate quarrying poses serious threats to the unique flora and fauna on the granitic hillocks. Some of the low altitude hillocks on either side of the national highways were destroyed for expansion of the highway. The hillocks near human settlements have become dumping grounds for disposal of wastes which adversely affects the soil quality and vegetation. Invasion of *Chromolaena odorata* (L.) R.M. King & H. Rob. and *Mimosa diplotricha* Sauvalle and promotion of monoculture plantations of *Tectona* and *Acacia* were found to retard the growth of indigenous flora of the hillocks. During the dry phase, most of the rocky outcrops were dominated by fire-indicating taxa like *Hyptis suaveolens* (L.) Poit. and grasses like *Apluda mutica* L. which easily catch fire and lead to the loss of natural vegetation. Some of these hillocks are susceptible to landslides owing to indiscriminate quarrying which in turn destroy entire flora and fauna of associated microhabitats.

CONCLUSIONS

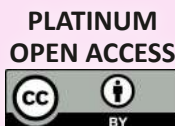
All microhabitat categorizations are limited by factors such as soil depth, water content and other seasonal variations and there is no clear physical demarcation between the habitats. The onset of the monsoon season leads to dispersion of water in soil-filled depressions or even flat surfaces and hence overlay in species composition can be observed in these habitats. While some taxa were restricted to a single microhabitat, other species were able to grow in an array of closely similar microhabitats although their dominance levels varied with reference to specific habitat inclinations and niche.

The documentation of taxa during the wet phase alone could record 121 elements belonging to 37 families distributed in eight different microhabitats which are ephemeral and seasonal. The adaptive strategies provided by such microhabitats support taxa which have narrow ecological amplitude and share narrow ecological niches. Hence conservation of such microhabitats becomes inevitable as far as these vulnerable habitats are concerned as they are prone to many human-induced threats along with biological invasions. Natural calamities such as landslides and forest fires and anthropogenic activities including quarrying and urbanization reduce the natural vegetation of these unique habitats. Hence, conservation strategies have to be formulated for the maintenance of floristic diversity in these unique ecosystems.

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