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PLATINUM
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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$^{0}$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, Nelliyampathy, Olavakkode, Ottappalam, Walayar, and Mannarkkad was carried out between June 2016 and May 2018. The sampling locations lie between 10.551–11.010 $^{0}$N and 76.161–76.828 $^{0}$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., *Burmannia 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 unioloides* (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,

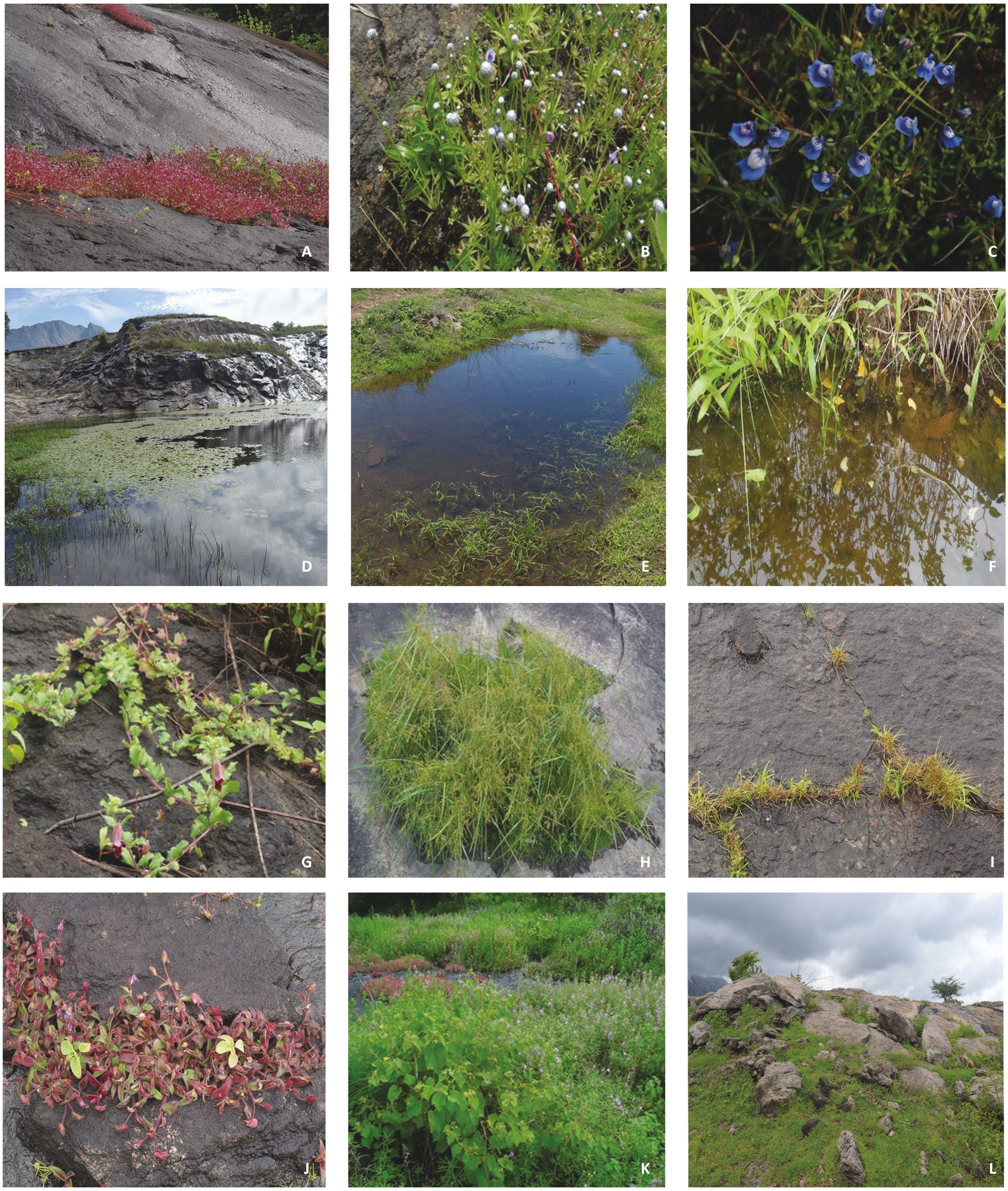

**Image 2. Wetphase microhabitats in rocky hillocks: A–C—Ephemeral flush vegetation (A–*Cyanotis papilionacea* (Burm.f.) Schult. & Schult.f.; B–*Eriocaulon pectinatum* Ruhland; C–*Utricularia lazulina* P. Taylor) | D—Rock pools | E&F—Small ephemeral pools | G—Exposed rock surfaces (*Sesamum prostratum*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

| | Botanical name | Family | Micro-habitats |
|---|---|---|---|
| 75 | *Ludwigia hyssopifolia* (G.Don) Exell | Onagraceae | SFD |
| 76 | *Marsilea quadrifolia* L. | Marsileaceae | SEP, RP |
| 77 | *Melochia corchorifolia* L. | Malvaceae | SFD, SRA |
| 78 | *Microcarpaea minima* (K.D.Koenig ex Retz.) Merr. | Plantaginaceae | SFD |
| 79 | *Mitrasacme indica* Wight | Loganiacaeae | SFD |
| 80 | *Mitrasacme pygmaea* R.Br. | Loganiacaeae | SFD |
| 81 | *Monochoria vaginalis* (Burm.f.) C.Presl | Pontederiaceae | SEP |
| 82 | *Murdannia semiteres* (Dalzell) Santapau | Commelinaceae | EFV, ERS |
| 83 | *Murdannia spirata* (L.) G.Brückn. | Commelinaceae | SFD |
| 84 | *Nymphaea nouchali* Burm.f. | Nymphaeaceae | RP |
| 85 | *Oldenlandia corymbosa* L. | Rubiaceae | SFD, RCF |
| 86 | *Oldenlandia diffusa* (Willd.) Roxb. | Rubiaceae | SFD |
| 87 | *Oldenlandia dineshii* Sojan & Suresh | Rubiaceae | ERS, SFD |
| 88 | *Ophioglossum nudicaule* L.f. | Ophioglossaceae | SFD |
| 89 | *Oryza rufipogon* Griff. | Poaceae | SFD |
| 90 | *Osbeckia muralis* Naudin | Melastomataceae | B, ERS, RCF, SFD |
| 91 | *Oxalis corniculata* L. | Oxalidaceae | B, SFD |
| 92 | *Pandanus canaranus* Warb. | Pandanaceae | RP |
| 93 | *Parahemionitis cordata* (Hook. & Grev.) Fraser-Jenk. | Pteridaceae | B |
| 94 | *Parasopubia delphiniifolia* (L.) H.-P.Hofm. & Eb.Fisch. | Orobanchaceae | ERS, SFD |
| 95 | *Polygala chinensis* L. | Polygalaceae | SFD |
| 96 | *Polygala persicariifolia* DC. | Polygalaceae | ERS, RCF |
| 97 | *Rhamphicarpa fistulosa* (Hochst.) Benth. | Orobanchaceae | ERS, SFD |
| 98 | *Rhynchosia rufescens* (Willd.) DC. | Fabaceae | RCF, SFD |
| 99 | *Rhynchosia suaveolens* (L.f.) DC. | Fabaceae | RCF, SFD |
| 100 | *Rotala indica* (Willd.) Koehne | Lythraceae | SEP |
| 101 | *Rotala malampuzhensis* R.VNair | Lythraceae | SEP |
| 102 | *Rotala mexicana* Schltdl. & Cham. | Lythraceae | SEP, RP |
| 103 | *Sesamum prostratum* Retz. | Pedaliaceae | ERS, SFD |
| 104 | *Setaria pumila* (Poir.) Roem. & Schult. | Poaceae | SFD, SRA |
| 105 | *Sida acuta* Burm.f. | Malvaceae | SFD, SRA |
| 106 | *Smithia blanda* Wall. | Fabaceae | SFD |
| 107 | *Smithia conferta* Sm. | Fabaceae | SFD |
| 108 | *Spermacoce alata* Aubl. | Rubiaceae | SRA |
| 109 | *Spermacoce articularis* L.f. | Rubiaceae | SRA |
| 110 | *Spermacoce hispida* L. | Rubiaceae | SRA |
| 111 | *Spermacoce ocymoides* Burm.f. | Rubiaceae | SFD, SRA |
| 112 | *Spermacoce pusilla* Wall. | Rubiaceae | RCF, SFD |
| 113 | *Striga angustifolia* (D.Don) C.J. Saldanha | Orobanchaceae | ERS, SFD |
| 114 | *Striga asiatica* (L.) Kuntze | Orobanchaceae | ERS, SFD |
| 115 | *Tephrosia maxima* (L.) Pers. | Fabaceae | SFD, SRA |
| 116 | *Tephrosia purpurea* (L.) Pers. | Fabaceae | ERS, SFD, SRA |
| 117 | *Utricularia aurea* Lour. | Lentibulariaceae | RP |
| 118 | *Utricularia lazulina* P.Taylor | Lentibulariaceae | EFV |
| 119 | *Utricularia graminifolia* Vahl | Lentibulariaceae | EFV |
| 120 | *Xyris pauciflora* Willd. | Xyridaceae | ERS |
| 121 | *Zornia gibbosa* 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–*Theriophonum 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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