Journal of Threatened Taxa | www.threatenedtaxa.org | 26 March 2013 | 5(5): 3935–3962

CRITICAL ECOSYSTEM PARTNERSHIP FUND

Western Ghats Special Series

REVIEW

ISSN
Online 0974-7907
Print 0974-7893

OPEN ACCESS

Status review of Rocky plateaus in the northern Western Ghats and Konkan region of Maharashtra, India with recommendations for conservation and management

Aparna Watve

34/6, Gulawani Maharaj Road, Pune, Maharashtra 411004, India
aparnawatve1@gmail.com

Abstract: Rocky plateaus in the northern Western Ghats and Konkan region are specialized habitats belonging to the general habitat category of Rock Outcrops. Their distribution and classification is presented here, with details of microclimate and edaphic features. Microhabitats on the rocky plateaus have been described along with characteristic species assemblages and changes in them due to biotic pressure. Ecological assessment of representative sites show high species richness and diversity (H'). A review of current knowledge about endemic flora and fauna on the rocky plateaus shows a large number of endemic species of flora and fauna, of which many are regionally assessed as threatened. Localized diversification within floral and faunal genera is common and indicates active speciation. Most localities except those within protected areas are affected by biotic pressures and there is no specific legal protection for their rich biodiversity. The paper suggests needs for future research on the habitat and recommends conservation and management actions based upon the ecology of the habitat.

Keywords: Biodiversity, endemic, ferricrete, Konkan, mesa, new taxa, northern Western Ghats, rocky plateaus, threats.

DOI: http://dx.doi.org/10.11609/JoTT.o3372.3935-62

Editor: Shonil Bhagwat, Open University and University of Oxford, UK

Date of publication: 26 March 2013 (online & print)

Manuscript details: Ms # o3372 | Received 04 October 2012 | Final received 18 January 2013 | Finally accepted 07 March 2013

Citation: Watve, A. (2013). Status review of Rocky plateaus in the northern Western Ghats and Konkan region of Maharashtra, India with recommendations for conservation and management. *Journal of Threatened Taxa* 5(5): 3935–3962; doi:10.11609/JoTT.o3372.3935-62.

Copyright: © Watve 2013. Creative Commons Attribution 3.0 Unported License. JoTT allows unrestricted use of this article in any medium, reproduction and distribution by providing adequate credit to the authors and the source of publication.

Funding: The work leading to this paper was partially funded by CEPF-ATREE small grants programme CEPF-ATREE-WGhats/SGPIWGSG113_BIOME_Watve (2012-2013); Department of Science and Technology for the Young Scientist grant SR/FT/L-15/2003 (2003-2006); Bombay Environmental Action Group for study of Panchgani plateau from 2004-2012.

Competing Interest: None.

Acknowledgements: I owe many thanks to my husband, Sanjay Thakur, for being a constant companion in all the hard field work and writing of this study. I gratefully acknowledge help of: Dr. Stefan Porembski, for taking a personal interest in guiding me about all the scientific work on rock outcrop habitats and constant support and encouragement in the initial research which was crucial for this study. I am indebted to: funding agencies, mentioned above; the MS reviewers; Agharkar Research Institute, Dr. Rao, ex-director, Dr. Mujumdar, ex-Head, Department of Botany, for laboratory facilities, for the SERC –Fast track project, Dr. Madhav Gadgil; Forest Department of Maharashtra, Shri. A. Joshi, PCCF, HoFF, Mr. Thosre, ex-MD, (FDCM), (Production and Marketing), Mr. Saiprakash, previously CCF Kolhapur, Mr. Limaye, previously DCF, Satara and field staff of Pune, Satara and Kolhapur forest divisions; Mr. & Mrs. Shirgaonkar, Dr. Swapna Prabhu, Vinay Kolte, Vikram Hoshing, Nina Hobbhahn, Gowri Mallapur for help in the field work; Mr. Ashok Captain, for most of the photographs used here; Dr. B.G. Kulkarni, Dr. Sachin Punekar, Dr. A. Khadkikar, Dr. M. Sardesai, Mr. G. Potdar, Dr. Mandar Datar for discussion and help in identification of species; Director and in-charge of Botanical Survey of India, Western Circle, Blatter Herbarium and Shivaji University herbarium; Dr. Erach Bharucha, Dr. V. Ghate, Dr. Hemant Ghate, Dr. A. Upadhye, Hema Ramani (BEAG), Dr. Jay Samant, Dr. M. Bachulkar, Dr. S.R. Yadav, Dr. M.K. Janarthanam for discussions which refined my concepts; to local people from various villages in the study area and many others. And most importantly, my parents Dr. Sujala and Dr. Vidyadhar Watve for great tolerance of my activities for over a decade without which this study was impossible.

Author Details: Aparna Watve holds a PhD in vegetation ecology and works as consultant for biodiversity research. She is currently coordinator of CEPF-ATREE funded project "Networking and Information Support for conservation of Rocky Plateaus in the Sahyadri-Konkan corridor" by Biome Conservation Foundation, Pune.

The publication of this article is supported by the Critical Ecosystem Partnership Fund (CEPF), a joint initiative of l'Agence Française de Développement, Conservation International, the European Commission, the Global Environment Facility, the Government of Japan, the MacArthur Foundation and the World Bank.

INTRODUCTION

The Western Ghats are an imposing north-south range of hills that form the western edge of the Deccan Plateau and the narrow strip of land that lies between them and the sea is known as the "Konkan-Malabar region". Western Maharashtra is composed of tall steep hills forming the northern part of the Western Ghats (henceforth referred to as NW Ghats) and the Konkan plains, which are interspersed with scattered low hills. The flat table-topped hills of the NW Ghats rise steeply to the east of the gently undulating plains of the Konkan. The present topography has resulted from intense physical and chemical weathering of basalt flows which in many areas has exposed duricrusts with scarce soil cover. Topographic maps of the region often mark these areas as "rocky scrub" or "stony waste" or simply as "sheet rock". Owing to the scarcity of woody species or forest cover the plateaus appear devoid of vegetation in remote sensing images. Wastelands Atlas of India by the National Remote Sensing Centre and Ministry of Rural Development (2010) shows extensive "Category 22" (barren rocky /stony waste areas) in Kolhapur, Pune, Satara, Ratnagiri and Sindhudurg districts, which in reality are rocky plateaus with high biodiversity value. The wasteland status has been easily exploited for acquiring rocky plateaus for mining, wind farms and infrastructure projects throughout the study area. Owing to this, only a small fraction of the rocky plateaus remain undisturbed, mostly in the protected areas or inaccessible areas.

This paper reviews previous knowledge on the physical and biological environment of the rocky plateaus in the Western Ghats and Konkan region of Maharashtra. Based on detailed primary and secondary qualitative observations and quantitative assessments it discusses the diversity of organisms occurring on this specific habitat. Current biotic pressures and disturbance to the sites are documented, and conservation and management actions are suggested.

Distribution and classification of rocky plateaus in study area

The Western Ghats mountain range stretches from Navapur on the Gujarat-Maharashtra border to Kerala and is almost continuous with the exception of a gap near Palakkad. It thus traverses different bioclimatic zones and has a pronounced south-north gradient of increasing dry period length. The northern Western Ghats (NW Ghats) and Konkan differ in geology and bioclimate from the southern Western Ghats (SW Ghats) and the Malabar region. Jog et al. (2002) have described the general geology and geomorphology of the NW Ghats and Konkan. The crest of the NW Ghats is on average 1000m, but reaches up to 1400m in some areas (e.g., Mahabaleshwar).

The NW Ghats and the Konkan lie approximately between $15^{0}60'$ & $20^{0}75'$N and are composed entirely of Deccan flood basalts, except in the southernmost tip of the Konkan. Basalt is an igneous rock formed from the cooling of the Deccan Trap lava flows, which forms the base rock of the western part of Maharashtra State. The Deccan Traps are mostly arranged in flat layers giving rise to the flat plains of the Deccan and the layered aspect characteristic of the Western Ghats hills in Maharashtra.

The basalt has weathered to laterite on the hill tops but the laterite cover has eroded in most places and remains only as caps on the summits of the Western Ghats escarpment, especially south of $18^{0}20'$N (Widdowson & Cox 1996). Laterite is a product of intense chemical weathering in a leaching environment and subsequent or simultaneous induration (Jog et al. 2002). Laterite can be found just below the ground as a hard, pavement-like surface which weathers by action of water courses, leaving the laterite as a resistant cap on upland mesas and plateaus, e.g., on Western Ghats hill tops. Laterites have also formed on the Deccan Traps along the plains of the Konkan coast, to which weathered laterite material from the Western Ghats ranges is added.

North of $18^{0}20'$N (roughly Mahabaleshwar area) the lateritic cap has weathered away and the underlying basalt is exposed on the summits in the form of basaltic plateaus. Details of origin, evolution and geomorphology of these regions are discussed in Gunnell & Radhakrishna (2001) and Jog et al. (2002). Many of the plateaus in this region have undergone heavy weathering and have well-formed soil layers which support woody or forest growth. Forested plateaus like Mahabaleshwar or Bhimashankar have been discussed by Puri & Mahajan (1960), Pascal (1988), and Ghate et al. (1997). However, this work primarily deals with the exposed outcroppings of laterite and basalt in the form of rocky plateaus as they show many special features of floral and faunal communities.

The broad term, 'rock outcrop' has been used for landforms ranging from cliffs, isolated rocky hills, inselbergs (Porembski & Barthlott 2000), ferricretes and other rocky exposures of varying geological history. Wiser & White (1999) identified rock outcrops by prevalence of bare or lichen-encrusted bedrock that separates them from adjacent habitats; with on average 55% ground surface of exposed rock, while Porembski & Barthlott (2000) have emphasized upon the "naturally formed" or "primary outcrops" which are exposed due to geological reasons such as volcanism, weathering etc. The exposure of large rock surface leads to special microclimatic conditions such as high exposure to sun, shallow soils, water stress or excess etc., which in turn influences the prevalent plant communities. This leads to many similarities in terms of community assemblages and adaptive strategies of mainly flora and to a certain extent fauna associated with these habitats. The rocky plateau biodiversity described here, on ferricretes as well as basalt plateaus, is ecologically related to that on the other types of rock outcrops across the world due to these similarities in microclimatic conditions. The rocky plateaus are categorized on the basis of the rock type and geomorphology into two main types, each further divided by altitude into two:

A. Ferricretes - are indurated platforms of laterite typically with wide and flat to gently sloping flat tops and edges marked by sharp cliffs. Most floristic literature of the region refers to these as "lateritic plateaus", without making clear distinction between the rocky lateritic plateaus and lateritic soil-covered plateaus. The map by Widdowson & Cox (1996) clearly shows the distribution of ferricretes in the western Maharashtra. They can be differentiated into:

A1. High-level Ferricretes (HLF) (Image 1) occur on High-Level Laterites between 15–18^{0}20'N, extend inland to 74^{0}E, and are located between 800 and 1400m (Widdowson & Cox 1996) in the districts of Satara, Kolhapur, Sangli, Ratnagiri, and Sindhudurg, which include the crestline of the NW Ghats. These also occur till the Belgaum District (Karnataka State), but not seen further southwards.

A2. Low-level Ferricretes (LLF) (Image 2) occur in the Low-level Laterites of Konkan plains between 50–200 m south of 18^{0}20'N in the Raigad, Ratnagiri and Sindhudurg districts, as well as all of Karnataka and the Kerala coast, extending from the sea coast to the foothills of the Western Ghats (see map by Gunnell 2001). They are much more extensively preserved than the high level laterites.

Ferricretes are often known as "tablelands" owing to the wide flat appearance and steep edges. In Maharashtra and Goa region they are known as "Sadas" in the local Marathi language. But the same term is also commonly applied to secondary exposures of laterites along hill slopes. (Image 4).

B. Basalt Mesa - The basalt outcrops are exposed on mesas between 18^{0}20'–21^{0}N & 73^{0}35'–73^{0}50'E (Image 3). These are areas where the upper layers of laterite have eroded to expose the underlying basalt flows, and hence can occur at any altitude depending upon the degree of weathering. Many of the hill forts of Maharashtra State have exposed hilltops of basalt. However, flora and fauna of basalt mesas (BM) at altitudes of 900–1100 m, especially at the crest of the NW Ghats, have many similarities with those of high-level ferricretes. These

Image 1. High Level Ferricrete (HLF)

Image 2. Low level Ferricrete (LLF)- Lateritic rocky plateau of Konkan

Image 3. Rocky plateau of Basalt (BM)

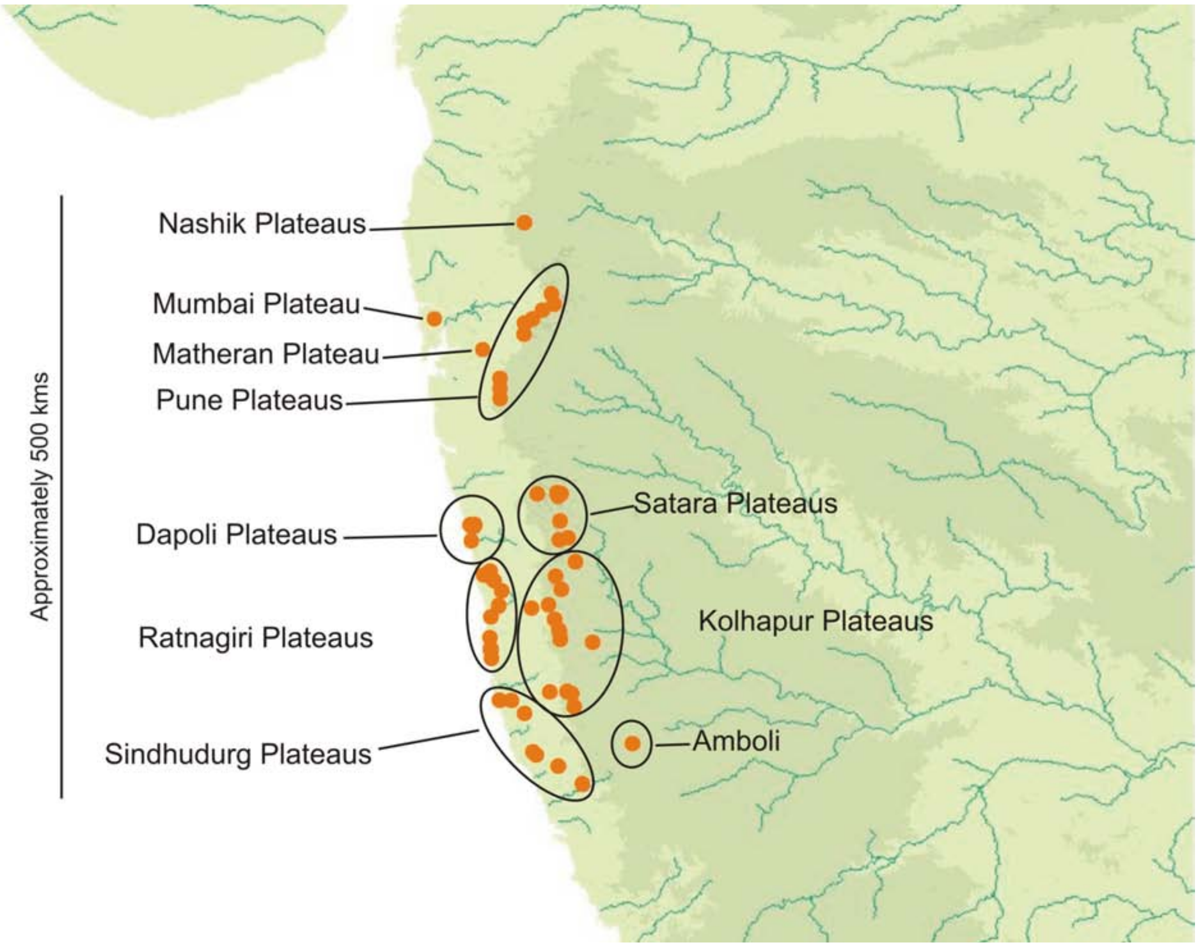


Figure 1. General distribution of Rocky Plateaus in Maharashtra (For details: See table 1)

Image 4. Lateritic exposures along slopes

occur in Pune, Akole, Ahmednagar and Nashik districts. Very often they are known as "katal" in Marathi. In the Bhimashankar area of Maharashtra the term "kharam" lands was mentioned to indicate basalt outcrops and scree on gentle slopes. These are areas deemed unsuitable for agriculture by local people. Fig. 1 shows the study area with localities studied for this review.

Low-level outcrops of basalt are known to occur in Thane and Mumbai areas (Kanheri Caves), but they have not been surveyed in detail and hence are not discussed in this paper.

Review of literature

Rock outcrops of Africa, the Americas and Australia have been extensively studied for more than three decades. The distinctness of rock outcrops from surrounding habitats is a major factor which leads to exclusivity of the plant diversity on them. Hence they have been described as "terrestrial habitat islands" and the microhabitats on them as "islands upon islands" (Porembski et al. 2000a). Azonal vegetation on tropical inselbergs in Africa, Australia and America has been studied by several researchers such as Burbanck & Platte (1964), Wyatt (1997), Porembski & Barthlott (2000b), and Burke (2003). But there is in general a scarcity of information regarding rock outcrop habitats of India. Globally, inselbergs of granite, sandstones, schists etc. have been studied in detail, but the same is not true for ferricretes and mesas. Ferricretes are known to be rich in species diversity, endemics and edaphic specialists (Verboom & Pate 2001), but only a few studies describe their vegetation (Porembski et al. 1994, 1997; Porembski & Watve 2005).

The only detailed information available on the distribution of ferricretes and mesas of the study area is from the geomorphological and geological literature. Geological Survey of India has published data on bauxite deposits of Maharashtra ferricretes. However, data on floristic and faunistic diversity remains scarce and widely scattered.

Bharucha & Ansari (1963) were the first to analyze the herbaceous vegetation of slopes and scree of Western Ghats in relation to soil, slope and aspect. Chavan et al. (1973) studied the Kas Plateau area (Satara District) but the study also includes cliff, forest and slopes around the Kas ferricrete. Regional floristic studies have reported the occurrence of many narrow-niched endemic and habitat specialist angiosperms from lateritic plateaus (Bachulkar 1983; Deshpande et al. 1993, 1995; Yadav & Sardesai 2002). Mishra & Singh (2001) have documented threatened plants of Maharashtra, of which many are reported exclusively from ferricretes or basalt outcrops. The first detailed enumeration of endemics from Goa by Joshi & Janarthanam (2004) includes many species specific to lateritic plateaus. The most recent study on floristics of lateritic plateaus by Lekhak & Yadav (2012) analyses angiosperm diversity in 10 sites of high level ferricretes.

Ecological studies and floristic and faunal observations on basalt and laterite outcrops have been published by Watve (2003a,b, 2006, 2007, 2008), and Watve & Thakur (2006). A review paper on the biodiversity and ecology of rocky plateaus (Watve 2010) has been included as a part of the Western Ghats Ecology Expert Panel (WGEEP) report on ecologically sensitive areas of the Western Ghats.

In spite of these studies there is little awareness at policy level regarding the special nature of rocky plateau biodiversity, and their conservation requirements need to be emphasized. Within the last decade many rocky plateaus have been taken over by mining, windfarms, construction of townships and industries. Tourism has been growing in some of the scenic areas putting severe pressure on fragile habitats. The management of these pressures is often misguided due to poor understanding about the special ecological features of the habitat. The measures used for protection of forest or grassland habitats are not appropriate, as the ecological processes on rocky plateaus are different in nature. The lack of baseline information regarding rocky plateau ecology has severely hampered efforts of management and conservation. Thus this is an effort to collate baseline information with a view to highlight conservation and management priorities.

METHODS

The distribution of rocky plateaus in Maharashtra was mapped using extensive geological literature (Gunnell & Radhakrishna 2001; Didee et al. 2002). Topographic maps published by the Survey of India and mineral maps published by Geological Survey of India were screened to identify possible occurrences. Primary observational information from mountaineering, trekking literature was also screened. Records of bauxite deposits which indicate the distribution of ferricretes were also surveyed. Remote Sensing data was screened wherever available (Watve 2007), however it does not always provide a reliable record as many other non-forested or degraded areas look similar to the rocky plateaus in RS imagery. Rigorous ground-truthing was conducted between 2001–2012 and field information was documented regarding disturbance status (qualitatively ranked low, moderate, high) and current threats.

Floristic, faunal and ecological information about the rocky plateaus have been collected from primary observations since 2001 and also from published literature.

Plant communities on six representative sites (two sites of high-level ferricretes each in Kolhapur District and Satara District and two basalt mesas in Pune District) were quantitatively studied and monitored between 2004–2006. At each site, five transects were laid down, at a distance of about 300m. Five permanent quadrats of 1x1 m were marked per transect at distance of 10m each. A total of 145 quadrats were monitored over three years to document seasonal variation in plant species composition and richness. Physical and chemical properties of the soil of ephemeral flush vegetation and shallow depressions were analyzed from eight NW Ghats plateau localities.

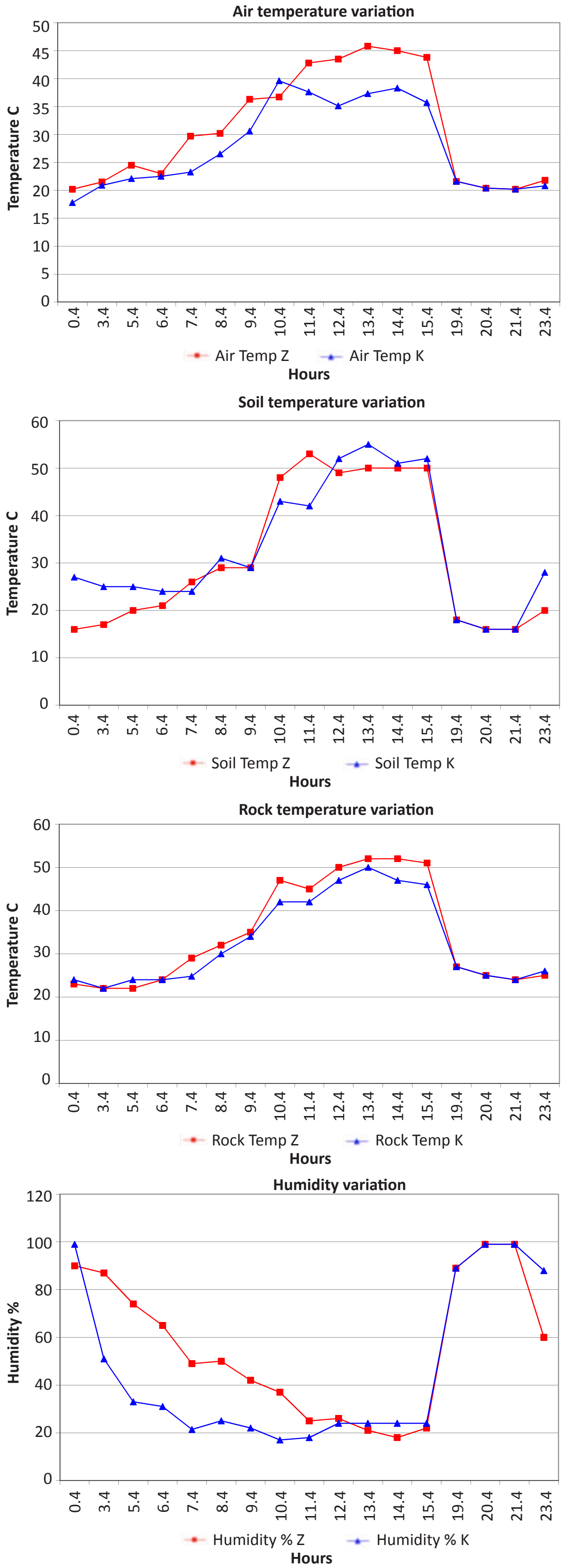
Regional floristic literature listing endemic species (Sharma et al. 1996; Singh & Karthikyan 2000; Tetali et al. 2000; Singh et al. 2001) was screened, for understanding endemism. Ecological data from protologues, primary observational papers and enumerations of endemic and threatened species was collated and habitat description was checked along with herbarium specimen data from BSI and AMH. Based on these, endemic species of angiosperms and pteridophytes reported to occur on the known rocky plateau localities were listed.

Checklists and description records of fauna were screened to identify species which primarily inhabit rocky plateaus. Primary and secondary observations from zoologists were used to identify species specific to rocky plateau habitats.

RESULTS AND DISCUSSION

A total of 67 locations are described in the Table 1, grouped in the four rocky plateau types. Their exact locations are not mentioned due to high sensitivity of the habitats and species. Watve (2007, 2010) has reported climatic and microclimatic (soil, rock, air, temperature and humidity) conditions on rocky plateau sites. Insolation and scarcity of soil cause the microclimate on the plateaus to be more extreme than the surroundings. Seasonal variation in microclimate strongly influences the plant communities (Watve 2007). Diurnal variation is also extreme, as can be seen from Figs 2a–d. During the dry period, the thin soil layer does not hold any moisture and the conditions are almost arid. However, in monsoon, the impermeable nature of the hard rock surface leads to waterlogging of the soil and creation of ephemeral wetlands. As seen from this, the microenvironment of the rocky plateaus tends to extremes, from xeric to water logged.

Table 2 shows that soil varied from sandy to sandy loam type with good water holding capacity and normal EC. It was highly acidic (4.5–6), rich in organic carbon, available nitrogen and available potassium. Lekhak & Yadav (2012) relate the presence of carnivorous plants on the plateau to the poor nitrogen, phosphorous and potassium (N,P,K) values. However, the soil is poor only in available phosphorus. In addition to the carnivorous plants, many other plant species are able to survive in the habitat. Hence, the abundance of carnivorous species on rocky plateaus might be mainly because of reduced competition from other generalist species as a result of harsh physical environment, acidic soils and low levels of available phosphates. Presence and dominance of other plant adaptive strategies such as poikilohydry, geophytic, therophytic, hydrophytic species seen on rocky plateaus (Watve 2007, 2010; Lekhak & Yadav 2012) is also a result of extreme seasonality in climate as well as microclimate from seasonally wet to dry.



Figures 2 a–d. Diurnal changes in microclimate on a midsummer day (in May 2004): readings from two sites

Table 1. Details of locations studied

Regions	Villages	Local names	District	Outcrop type	Tar Road on site	Land ownership	Threat	Disturbance
High Level Basalt								
1. Nashik area	Anjaneri	Anjaneri	Nashik	BM	N	Partly RF	Tourism	Low
2. Ahmednagar	Harishchandragad	Harishchandragad	Ahmednagar	BM	N	Harishchandragad Kalsubai WS	Trekking	Low
3. Malshej Ghat area	Malshej	Malshej Ghat	Ahemdnagar	BM	N	Mostly private	Tourism	High
4. Ghatghar area	Ghatghar	Naneghat	Pune	BM	Y	partly RF	Tourism	Low
5. Inglun area	Ambe Hatvij	Khadaktala, Durguwadi (Site D)	Pune	BM	Y	Partly RF	Temple tourism	Low
6. Bhimashankar area	Ahupe (Site A)		Pune	BM	Y	Bhimashankar WS, forest village	Land conversion to agriculture	Moderate
7. Bhimashankar area	Kondhwal		Pune	BM	Y	Bhimashankar WS	Plantation in the past	Low
8. Lonavla area	Kune, Lonavla	Kune Plateau	Pune	BM	Y	Private	Land-conversion for housing	High
9. Ambavane area	Ghusalkhamb/ Lonavla	Sakharpathar	Pune	BM	Y	Private, ?	Commercial tourism	Very high
10. Ambavane area	Ambavane	Korigad	Pune	BM	N	Archaeological Survey of India (RF?)	Tourism	Low
Low Level basalt								
11. Mumbai	Sanjay Gandhi NP	Kanheri	Mumbai	LBM	Y	Within Sanjay Gandhi NP	Tourism	High
High Level ferricrete								
12. Raigad District	Matheran	Matheran	Raigad	Between HLF and LLF	N	Matheran ESZ	Tourism	High
13. Panchgani area	Godawali/ Panchgani	Panchgani Tableland/Asia plateau	Satara	HLF	Y	Mahabaleshwar Panchgani ecosensitive zone Declared natural heritage site, Conservation Zone	Commercial landscape tourism	Very high
14. Panchgani area	Khingar	Panchgani Tablelands	Satara	HLF	N	Conservation Zone	Grazing	Very low
15. Panchgani area	Dandeghar	Panchgani Tablelands	Satara	HLF	N	Conservation Zone	Grazing	Very low
16. Panchgani area	Ambral	Panchgani Tablelands	Satara	HLF	N	Conservation Zone	Tourism	Low
17. Panchgani area	Rajapuri	Panchgani Tablelands	Satara	HLF	N	Conservation Zone	Tourism	Low
18. Mahabaleshwar area	Mahabaleshwar	Near Venna Lake	Satara	secondary laterite exposure on slopes	Y	Mahabaleshwar Panchgani ecosensitive zone	Commercial landscape tourism	High
19. Kas area	Kas (Site K)	Apti papdi, dhang sada, thanoba sada	Satara	HLF	Y	RF, private	Flower tourism	Moderate
20. Chalkewadi area	Boposhi	Boposhi sada	Satara	HLF	Y	Private	Windfarms	High
21. Chalkewadi area	Chalkewadi (Site C)	Sasedurg sada, kumbali cha bhomad, revalyacha sadal	Satara	HLF	Y	Some part in Koyna WS	Windfarms	High
22. Mhavashi area	Mhavashi	Kalaki sada, Sada Vaghapur, Dhusale sada; Dadoli sada Mhavashi sada	Satara	HLF	Y	some part RF, private	Windfarm	High

Regions	Villages	Local names	District	Outcrop type	Tar Road on site	Land ownership	Threat	Disturbance
23. Koyna WS area	Koyna WS group	Kokan Sada and others	Satara	HLF	N	Koyna WS	**None**	Probably none
24. Near Koyana WS	Valmik pathar		Satara	HLF		Private, RF	Windfarms	High
25. Chandoli NP area	Gothane	Kala sada, Danana sada, malivne sada, toran sada	Sangli	HLF	N	Chandoli WS	None	None
26. Chandoli NP area	Zolambi		Sangli	HLF	N	Chandoli NP	Local	None
27. Chandoli NP area	Rundiv and other plateaus of Chandoli NP		Sangli	HLF	N	Chandoli NP	None	None
28. Amba ghat area	Amba		Kolhapur	secondary laterite	N	RF	Tourism	Moderate
29. Amba ghat area	Manoli	Zendyacha dongar (Site Z)	Kolhapur	HLF	N	RF	Mining proposed	None
30. Amba ghat area	Girgao	Girgao	Kolhapur	HLF	Y	Private	Mining	High
31. Malaiwad	Malaiwad	Malaiwad	Kolhapur	HLF	Y	Private	Mining	High
32. Burki	Burki	Burki	Kolhapur	HLF	N	RF	Grazing	Low
33. Kolhapur area	Mahalunge	Masai pathar (Site M)	Kolhapur	HLF	Y	Some part RF	Temple tourism	Low
34. Radhangari area	Patpanhal, Phejiwade	Idarganj /Idardung, Ijiwade sada, Phejiwade sada	Kolhapur	HLF	N	Radhanagari WS	None	None
35. Radhangari area	Durgamanwad	Durgamanwad	Kolhapur	HLF	Y	Private	Bauxite mining	Impact mitigation in progress
36. Dajipur area	Dajipur	Manbet sada, Sawrai sada	Kolhapur	HLF	N	Radhanagari WS	None	None
37. Amboli	Amboli	Choukul sada, Hiranyakeshi sada, Khamtyahca sada	Sindhudurg	HLF	N	RF	Grazing	Low
38. Chandgad area	Mogalgad	Mogalgad	Kolhapur	HLF	N	Private	Mining proposed	low
39. Amboli	Kasarsada			HLF	Y	RF under mining lease	Old mining area	High
Low –level ferricretes								
40. Deogad –Kudal area	Devgad		Sindhudurg	LLF	Y	Private	Orchards	High
41. Deogad –Kudal area	Savantwadi		Sindhudurg	LLF	Y	Private	Infrastructure	High
42. Deogad –Kudal area	Nerurpar		Sindhudurg	LLF	Y	Private		
43. Deogad –Kudal area	Kudal		Sindhudurg	LLF	Y	Private	Infrastructure	High
44. Deogad –Kudal area	Aare		Sindhudurg	LLF	Y	Private	Grazing	Low
45. Deogad –Kudal area	Achirne		Sindhudurg	LLF	Y	Private	Grazing	Low
46. Deogad –Kudal area	Talebazar		Sindhudurg	LLF	Y	Private	Grazing	Low
47. Deogad –Kudal area	Deverukh		Sindhudurg	LLF	Y	Private	Infrastructure/ Quarries	Moderate
48. Ratnagiri area	Ratnagiri		Ratnagiri	LLF	Y	Private	Infrastructure	Moderate
49. Ratnagiri area	Dhopave		Ratnagiri	LLF	Y	Private	Grazing	Low
50. Ratnagiri area	Navazarwadi		Ratnagiri	LLF	Y	Private	Grazing	Low
51. Ratnagiri area	Guravvadi		Ratnagiri	LLF	Y	Private	Grazing / Quarries	Low
52. Ratnagiri area	Bhatvad		Ratnagiri	LLF	Y	Private	Grazing	Low
53. Ratnagiri area	Jakadevi		Ratnagiri	LLF	Y	Private	Grazing / Quarries	Low
54. Ratnagiri area	Pachir		Ratnagiri	LLF	Y	Private	Grazing	Low
55. Ratnagiri area	Ratnagiri airport		Ratnagiri	LLF	Y	Private/Revenue	Infrastructure	Moderate

Regions	Villages	Local names	District	Outcrop type	Tar Road on site	Land ownership	Threat	Disturbance
56. Ratnagiri area	Ratnagiri MIDC		Ratnagiri	LLF	Y	Private/Revenue	Infrastructure	Moderate
57. Ratnagiri area	Dingni		Ratnagiri	LLF	Y	Private	Grazing	Moderate
58. Ratnagiri area	Dorle		Ratnagiri	LLF	Y	Private	Grazing	Moderate
59. Ratnagiri area	Ambolgadh		Ratnagiri	LLF	Y	Private	Tourism	Moderate
60. Ratnagiri area	Jaitapur		Ratnagiri	LLF	Y	Private	Nuclear power plant	High
61. Ratnagiri area	Abloli		Ratnagiri	LLF	Y	Private	Grazing	Low
62. Ratnagiri area	Dodavli		Ratnagiri	LLF	Y	Private	Grazing	Low
63. Dapoli area	Tere Vayangani,		Ratnagiri	LLF	Y	Private	Grazing	Low
64. Dapoli area	Male		Ratnagiri	LLF	Y	Private	Grazing	Low
65. Dapoli area	Nigde		Ratnagiri	LLF	Y	Private	Grazing	Low
66. Dapoli area	Olgaon		Ratnagiri	LLF	Y	Private	Quarrying	Moderate
67. Dapoli area	Umbarle		Ratnagiri	LLF	Y	Private	Grazing	Low

Y - Yes; N - No; WS - Wildlife Sanctuary; NP - National Park

Table 2. Soil properties

Soil	Site Z EFV	Site Z SD	Site M EFV	Site M SD	Site K EFV	Site K SD	Site C EFV	Site C SD	Site D EFV	Site D SD
pH	4.93	5.18	5.6	5.88	5.13	5.88	5.34	5.45	5.66	6.06
	highly acidic	higly acidic	medium acidic	medium acidic	higly acidic	medium acidic	medium acidic	medium acidic	medium acidic	slightly acidic
Electrical conductivity (EC)	0.18	0.08	0.08	0.05	0.09	0.05	0.09	0.08	0.07	0.07
	average	average	average	average	average	average	average	average	average	average
Organic Carbon % (OC)	4.12	7.38	4.47	6.8	6.14	3.25	3.84	3.78	5.06	1.87
	very high	Very high	very high	Very high	Very high	Very high	Very high	Very high	Very high	Very high
Available N kg/ha	more than 701	more than 701	more than 701	more than 701	more than 701	more than 701	more than 701	more than 701	more than 701	more than 701
	very high	very high	very high	very high	very high	very high	very high	very high	very high	very high
Available P kg/ha	21.15	20.04	18.37	18.37	18.92	20.59	17.81	20.59	17.81	17.81
	less	less	less	less	less	less	less	less	less	less
Available K kg/ha	590.02	427.39	667.97	200.26	427.39	292.99	314.5	419.33	336	231.17
	very high	very high	very high	medium	very high	medium	high	Very high	high	medium
Sand %	49.9	60.63	55.83	57.58	49.4	88.07	74.38	56.76	66.73	67.92
Silt %	38.37	23.8	27.02	22.84	29.46	5.87	17.82	25.98	17.68	13.61
Clay %	11.72	15.5	17.17	19.53	20.89	6.02	7.78	17.21	15.3	17.49
Soil type	loam	sandy loam	sandy loam	sandy loam	loam	sandy	sandy loam	sandy loam	sandy loam	sandy loam
Water holding capacity (WHC)	66.72	64.36	124.98	52.69	88.31	32.85	59.31	61.4	86	41.22
Density (g/cc)	2.15	1.49	1.08	1.67	1.44	1.94	1.81	1.65	1.48	1.83
Porosity %	62.02	49.97	58.7	47.59	57.08	40.97	52.35	50.72	57.16	45.56

Description of microhabitats and vegetation (Images 5–10)

A standardized microhabitat classification has not yet been created for ferricretes or basalt plateaus. Plant species commonly seen in the microhabitats have been described by Watve (2003a, 2010) and Lekhak & Yadav (2012). These papers have used and adapted when necessary the microhabitat classifications used for ferricretes and inselbergs (Porembski et al. 1994, 1997, 2000a; Seine et al. 1998; Jacobi et al. 2007).

The ferricretes or basalt mesas in NW Ghats and Konkan, do not have microhabitats as clearly demarcated as on inselbergs. Due to the heavy monsoon, all depressions or flat surfaces and even boulders in depressions become waterlogged during the rains. Thus, there is much overlap seen between species in microhabitats. Some species are able to grow in closely similar microhabitats, e.g., Lekhak & Yadav (2012) describe *Aponogeton satarensis* as growing in SFD (Soil filled Depressions) as well as SEP (Small Ephemeral Pools). *Utricularia albocaerulea, U. purpurascens, Eriocaulon sedgwickii* or *E. eurypeplon* are not restricted to Ephemeral Flush Vegetation (EFV) on ferricretes, but also seen growing in shallow depressions (SD) with soil 10–20 cm deep. They are able to grow in a range of microhabitats, but in lesser dominance in areas where grasses, sedges and other ephemeral flora can compete with them due to soil availability. Very few species, with specific adaptation such as *Nymphoides* spp. and *Wiesneria triandra* are restricted to a single microhabitat (ponds or water pools). Most of the species are able to grow across a wide range of soil depths and slopes, although their dominance varies as per the specific habitat requirements.

The microhabitat classification described here is based on Seine et al. 1998 and Porembski et al. 2000a, with some modifications as in Watve 2010 (Table 3). However, this and all other microhabitat classifications are limited by the fact that on the rocky plateaus there is no clear physical demarcation between the habitats. An appropriate classification specifically for rocky plateaus can be finalized only after detailed ecological studies from diverse rocky plateaus in India.

The general vegetation is similar to ephemeral communities from granitic rock outcrops—Inselbergs and iron rich plateaus—in East and West Africa and Brazil (Porembski et al. 1994, 1997; Jacobi et al. 2007). Presence of *Cyanotis*, *Neanotis, Murdannia, Drosera, Utricularia, Lindernia, Burmannia, Fimbristylis, Rhamphicarpa* matches with that on paleotropical inselbergs described by Porembski & Brown (1995) and Dörrstock et al. (1996).

Image 5. Cryptogamic crust with lichens and mosses

Image 6. Crevice vegetation

Image 7. Seasonal Rock Pools (SRPs) with *Wiesneria triandra*

Dominance of *Rotala* and *Dopatrium* in water-filled potholes is similar to the vegetation of seasonal rock pools described by Krieger et al. (2000). The presence of *Ceropegia, Dipcadi, Aponogeton, Utricularia, Euphorbia* corresponds to that of iron rich ferricretes of Rwanda and Zaïre described by Porembski et al. (1997). Insectivorous

Image 8. Shallow depressions with *Cyathocline lutea* flowering on basalt outcrops

Image 9. Deep depressions with *Pleocaulus sessilis*

Image 10. EFV on low level ferricretes (*Utricularia reticulata*)

plants are a characteristic of African as well as Indian outcrops. Thus the overall vegetation has close affinities to the palaeotropical regions.

Floral diversity

Herbaceous vegetation on six rocky plateau sites of the NW Ghats was monitored to document temporal changes in monsoonal diversity of six sites of high altitude plateaus. The sites Z,M,C,K were high level ferricretes (HLFs) and D,A were basalt mesas (BMs) (See Table 1 for details). A total of 145 quadrats were monitored for two years (2004–2005 on five sites and 2005–2006 on one site). The quadrats covered shallow depressions, seasonal rock pools, cryptogamic crust, boulders and ephemeral flush vegetation (EFV), thus representing the most common microhabitats on the NW Ghats plateaus. The data collected were analyzed to understand changes in species richness calculated as total species number (N) and diversity (H'- Shannon's diversity index). Results are presented in Table 4 and Fig. 3a,b.

Early phase of monsoon (July) was period of vegetative growth of most species and very few species (*Habenaria* spp., *Dipcadi* spp.) started flowering in this period. Plants of Cyperaceae, Poaceae, Eriocaulaceae started emerging but were only distinguishable at morphospecies level. Hence quantitative data of this phase was not completely reliable. Late phase of monsoon corresponded roughly to August end or September first week, which was a period of characteristic mass blooming mainly of non-grass families (Fabaceae, Eriocaulaceae, Lentibulariaceae, Rubiaceae) observed on all rocky plateaus. Species richness as well as species diversity peaked at this period as most species of forbs and grasses completed their growth during this period. The species richness as well as diversity declined again in the post monsoon (October) when most forbs withered away after completing growth and grasses (*Dimeria* spp., *Dichanthium* spp. *Ischaemum* spp.) dominated vegetation and reached seed dispersal stage.

Only a very few annuals and perennials were seen in the winter and summer period and species richness as well as diversity were very low (3–4 species). Of the selected sites, highest species richness and diversity were seen on site D, a basalt mesa in Pune District.

From a total of 145 quadrats (area 145m^2), 132 species were reported (Watve 2007) including 57endemic angiosperms. These included 126 angiosperms, three bryophytes (identified only as morphospecies) and three pteridophytes. Poaceae (36 sp.) and Fabaceae (14 sp.) were the most species-rich families in the microhabitats surveyed.

Lekhak & Yadav (2012) have reported more than 300 species from 10 sites. The number is likely to increase as more surveys are carried out. Rocky plateaus are not completely separated from surrounding habitats

Table 3. Description of microhabitats on rocky plateaus with associated flora

A. Vegetation of rock surfaces	
A1. **Cryptogamic vegetation of rock surfaces [R]**	Exposed rock surface commonly covered by cyanobacterial crust (Photo 5)
Associated flora	*Cyanobacteria, Nostoc* spp., crustose lichens (Parmeliaceae), green algae in peak monsoon
Function	1. Pioneer layer in terms of nutrient cycling on these extreme habitats 2. Supports small ephemerals like *Murdannia semiteres, Dimeria woodrowii* (LLF)
Disturbance	In outcrops heavily disturbed due to trampling (Panchgani Tableland) and mining (Kolhapur) this cryptogamic crust degrades, exposing underlying rock. Regeneration is slow, and hampers nutrient cycling
A2. **Cryptogamic vegetation of boulders [B]**	Loose boulders of few cms to 1-2m height, seen on all types outcrops in natural conditions
Associated flora	*Nostoc* spp., crustose lichens (Parmeliaceae), moss cushions, *Cheilanthus* sp., *Riccia* spp. and other liverworts.
Function	1. Support lithophytes (*Eria* spp., *Bulbophyllum, Aerides, Hoya* sp.) *Utricularia striatula, Arundinella* spp., *Neanotis* spp. are commonly seen 2. Hiding sites for invertebrates (scorpions, crickets) and herpetofauna such as Caecilians, Saw-scaled vipers etc.
Disturbance	On most of rocky plateaus near human habitation (Kas, Satara District, Konkan), boulders have been removed for making houses, roads, boundaries etc., severely affecting associated biodiversity and destroying hiding places of herpetofauna and many invertebrates.
B. Vegetation of rock crevices [CR]:	Crevices can vary in depth and width from few cms to about a meter depending upon the rock weathering processes. (Photo 6)
Associated flora	*Indopoa paupercula, Glyphochloa* spp., *Neanotis* spp., *Habenaria rariflora, Mollugo pentaphylla* var. *rupestris* and many other annuals or perennials *Merremia rhynchorhiza* is seen on lateritic exposures of Amboli (HLF) while *Merremia dissecta* is seen on Sindhudurg plateaus (LLF)
Function	1. Accumulate nutrients over several years, providing enriched soil for plants 2. Safe sites for perennials (*Ceropegia jainii, Flemingia nilghiriensis, Lepidagathis* spp., *Euphorbia* spp.)
Disturbance	In areas of mild disturbance such as grazing, trampling, they protect perennials. However, hardy weeds such as *Lantana camara* easily invade crevices (Panchgani Tableland)
C. Vegetation of depressions:	
C1. **Vegetation of water pools:**	
c1.1 Ephemeral or Seasonal Rock Pools [SRP]	Shallow pools of water form on all types of rocky plateaus. These can be further divided into two. (Photo 7)
C1.11Shallow rock pools	With gently sloping sides with 2-5cm deep water and thin film of accumulated soil. Ephemeral in nature, and dry up immediately if the rain stops. These are common on ferricretes and often form around sloping areas. These dry out within 4-5 days when rain stops. *Murdannia semiteres, Cyanotis fasciculata, Isoetes sp.* are often seen. A few individuals of hydrophytes typical of deep rock pools (see below) are also seen.
c1.12 Deep rock pools	Depressions with steep sides, with some amount of accumulated soil and water depth exceeding 10cms. Do not dry immediately if the rain stops. Pothole weathering of basalt creates deep pools. Water retention period varies but is generally more than SRPs and can be upto a month after rain stops. Water loving species are abundant.
Associated flora	The deep pools support a variety of hydrophytes depending on the soil depth and water depth. *Aponogeton* satarensis, *Eriocaulon tuberiferum* (HLF), *Eriocaulon* spp., *Pogostemon deccanensis, Rotala* spp., *Dopatrium junceum, Isachne* spp., *Pasapalum canarae, Eleusine indica, Rotala* spp., *Cyperus* spp., *Pycreas* spp., aquatic ferns (*Marsilea quadrifida, Isoetes* spp.), *Wiesneria triandra* (LAF) Inhabited by tadpole shrimps, fairy shrimps, odonate larvae, breeding places of diverse frogs
c1.2 Vegetation of Ponds	Deep depressions with around a meter or more of accumulated soil and water are common on all rocky plateaus. They retain water till end of winter but dry out completely in summer.
Associated flora	Floating as well as rooted hydrophytes. Green algae, *Nymphoides* spp., *Ludwigia*, *Myriophyllum oliganthum*, *Crinum viviparum, Aponogeton natans* (LLF), *Persicaria glabra* Edges of ponds support typical species *Polygonum plebeium, Heliotropium* spp., and ruderals (*Argemone mexicana)*
c 1.3 Vegetation of drainage channels [DR]:	Shallow drainage channels of 10 or more cm width or deep permanent waterchannels are seen on ferricretes (esp LLF). The deeper ones with accumulated soils support vascular plants.
Associated flora	*Eriocaulon dalzellii* in deep water channels (HLF, LLF) *Cryptocoryne* spp. along edges of drainage channels and waterpools.
Function	1. Water related microhabitats from drainage channels to shallow and deep pools and ponds perform important function of retaining water on this seasonally wet habitat. 2. Support a large amount of invertebrate (odonata, crustacea, other insects) and vertebrate (amphibians, wild mammals) fauna dependent on aquatic habitats, thus increase the overall biodiversity value of the habitat

Disturbance	Vegetation of shallow pools, deep rock pools and drainage channels shows many overlaps in floristic composition, and only the abundance of certain species can be used for defining habitat preference. Microhabitats C1.1-C1.3 are extremely susceptible to human and domestic animal disturbance. Ponds are regularly used by livestock till winter, leading to introduction of invasive flora. Addition of livestock dung pollutes water and affects natural fauna. Washing clothes, utensils in drainage channels, pools and ponds (esp. on LLF) adds detergents to aquatic system degrading the natural water quality. Human activities on rocky plateaus, (digging, construction of roads, houses, quarrying or mining) that affect the pattern of water drainage on the plateau have a long-term effect on all associated biodiversity. In some cases, digging of soil (e.g. for windmills) created secondary deep pools, thus leading to local increase in abundance of aquatics on Chalkewadi plateaus including *Aponogeton satarensis*. However, this was short lived as they were later filled with debris or used for vehicle washing leading to addition of automobile oil, strong detergents making the water unfit for indigenous flora and fauna.
C2 Soil filled depression	Flat areas on the gently undulating plateaus have layers of soil and humus accumulated over the years, may or may not be inundated in heavy monsoon, depending on the surrounding slope. On the inselbergs or other African hilly outcrops shallow depressions are well demarcated microhabitats. However, on ferricretes and mesas in study area, they cannot be easily distinguished visually and merge gradually with other microhabitats including EFV and the plateau surface appears flat. The underlying broad depressions in the actual rock surface are never obvious. For e.g. Panchgani Tableland is broadly convex but has fine layer of accumulated windblown material as discussed by Ollier & Sheth (2008). Therefore the terminology is defined here based only on soil depth to cover the broad range of variations seen. Lekhak and Yadav (2012) have defined this range under the terms Soil-Covered Areas (SCA) and SRA (Soil-Rich areas)
c 2.1 Shallow depressions [SD]	Areas with soil depth between 5-30cm, dominated by herbs. (Photo 8)
Associated flora	Common are *Paspalum canarae, Smithia* spp.*, Habenaria* spp. *Pycreas* spp.*, Jansenella* spp.*, Senecio dalzellii, Hedyotis stocksii, Coelachne minuta, Iphigenia* spp., *Linum mysorense* (HLF), *Chemicristae mimosoides, Pulicaria* spp.*, Senecio* spp., *Dipcadi concanense* (LLF), *Dimeria* spp.*, Cyperus* spp., *Fimbristylis* spp., Iscahemum spp. *Tripogon bromoides, Eragrostis unioloides, Curculigo orchioides, Hypoxis aurea, Dipcadi* spp. In undisturbed areas *Ceropegia jainii* can be seen in shallow depressions. Unlike ferricretes, basalt outcrops are dominated by shallow depressions, in which *Cyathocline lutea, Senecio dalzellii, Hygrophila serpyllum, Arundinella* spp. are locally abundant. *Ophioglossum* sp. is commonly seen fern in shallow depressions.
c2.2 Deep soil filled depressions	Areas of soil depth from 30cm-1m, tall herbaceous vegetation or low shrubs can develop. Often along the fringes or in deeply convex areas where weathered soil and humus have accumulated for several years. (Photo 9)
Associated flora	Common are *Impatiens lawii* and *Pleocaulus sessilis,* Poaceae (*Dimeria* spp.*, Eulalia* spp.*, Pseudodichanthium serrafalcoides* etc.), *Murdannia (M. simplex, M. lanuginosa), Cyanotis concanensis, Decaschistia trilobata* (HLF), *Swertia decussata* and grasses BM often have *Senecio bombayensis,* Acanthaceae (*Neuracanthus sphaerostachys, Strobilanthes* spp.) *Blumea* spp., *Adelocaryum* spp. *(A. coelestinum, A. malabaricum), Drosera* spp. These areas may also remain waterlogged during heavy monsoon, thus showing some overlap with the pool microhabitats, but don't ever have dominance of hydrophytes.
Disturbance	Human disturbance leads to introduction of many ruderals like *Gomphrena celosioides*, *Celosia argentea* on shallow depressions. Large herb growth is disturbed by trampling, grazing or burning. Footpaths on most rocky plateaus are devoid of natural flora and contain only hardiest species like *Eragrostis uniolodes*
D. Ephemeral flush vegetation [EFV]*:*	The original definition of EFV by Richards (1957) has been expanded by Porembski & Watve (2005) to include a plant community that occurs on flat, seasonally wet or even inundated ferricretes where percolation of water is impeded by the presence of a hard duricrust. It grows on shallow (2-5cm deep soils) through which water seeps through continuously. On the ferricretes and basalt mesas it develops in and around boulders, sloping rock surfaces, edges of depressions (Photo 10) There is considerable overlap in species amongst Shallow Depressions and EFV, as both are intergrading to high extent. During the quantitative study it was noted that soil depth and slope can vary considerably even within a small area of 20X20cms, thus making it impossible to clearly distinguish between these two microhabitats.
Associated flora	Common are *Utricularia* spp. (*U. purpurasense, U. albocaerulea, U. reticulata, U. praeterita*) *Drosera indica* in abundance along with *Eriocaulon* spp. (*E. eurypeplon, E. sedgwickii, E. odoratum, E. odoratum* etc.), *Burmannia coelestis*, *Trithuria konkanensis* (LLF), *Xyris* sp.
Disturbance	EFV is extremely vulnerable to human disturbance such as trampling. Continuous disturbance to flora by trampling destroys root mass that binds the soil of EFV together. Once the soil is loosened, washed off or transported, only a few species can grow in the absence of root mats and leads to immediate decrease of abundance of the typical EFV species.
E. Deep soil filled areas	soil depth of 1 m and above
	Stunted growth of *Memecylon umbellatum, Syzygium cumini, Catunaregam spinosa, Gnidia glauca* and associated climbers, *Ipomoea, Argyreia, Ceropegia* spp.*, Vigna vexilllata etc.* can be seen on the deep depressions, along the edges of the rocky plateaus, rock debris area. Ground orchids seen. They do not differ much from the surrounding grassland areas on shrublands on slopes.
Disturbance	Lopping of low trees and regular burning opens up these areas for extensive growth of tall herbs and low shrubs as a secondary succession. Hence, biotic pressure on the areas needs to be documented managing the plant communities in the areas of deep soil.

and some herbaceous species from scrub and forest, can grow in areas of deep soil adding to the species number.

Many species of cryptogams (green algae, blue green algae, lichens, liverworts) were seen on the rocky plateaus but were not identified to species level. G. Chitale (pers. comm. 2012) has documented saxicolous lichens in the study area, and has described many species from the rocky plateaus of Panchgani Tableland, Bhimashankar, Kas, Kolhapur and Junnar areas. A complete assessment

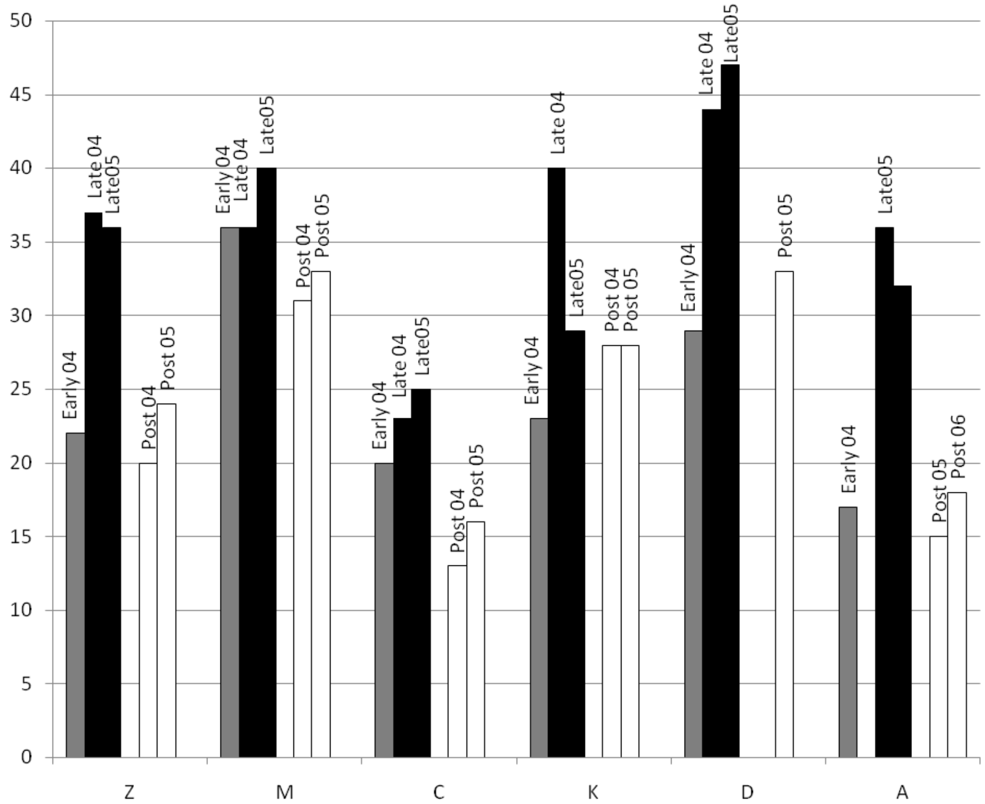


Figure 3a. Temporal changes in species number in monsoon (X - Sites, Y - total number of species)

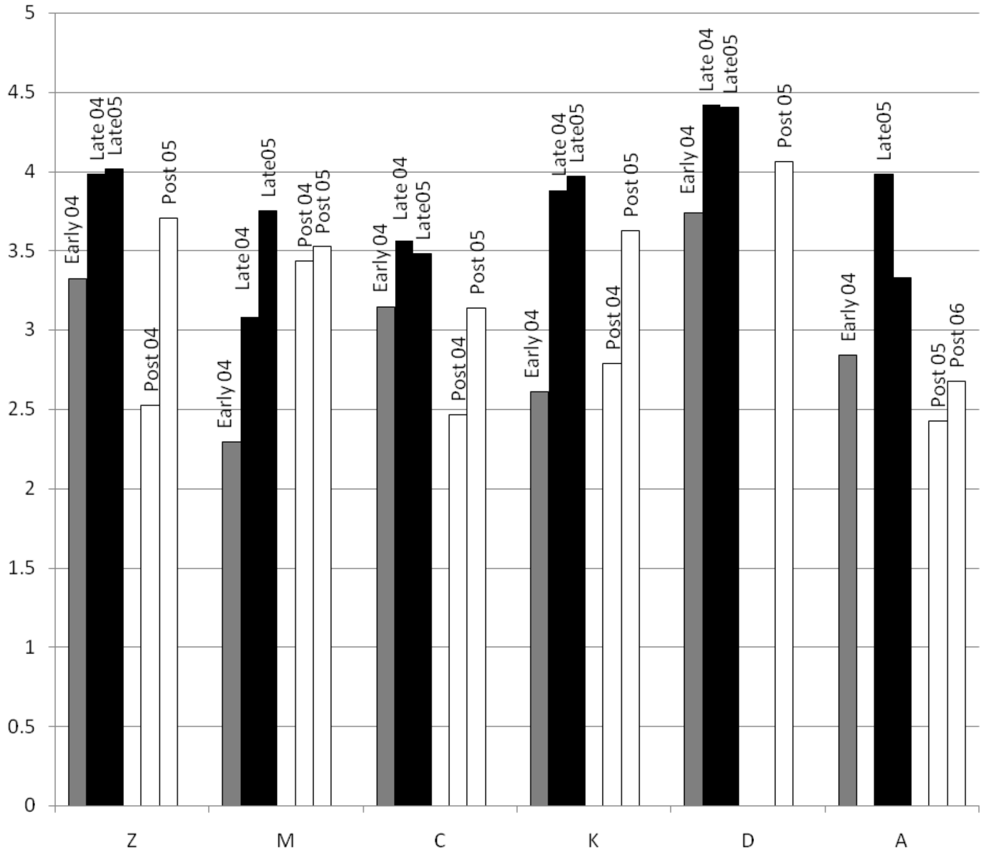


Figure 3b. Temporal changes in species diversity in monsoon (X - Sites; Y - H')

Table 4. Species richness and diversity values H' on six rocky plateaus

	N: Species richness						H': Shannon diversity index (log2)					
	Z	M	C	K	D	A	Z	M	C	K	D	A
Early 04	22	36	20	23	29	17	3.327	2.294	3.149	2.61	3.739	2.843
Late 04	37	36	23	40	44		3.984	3.082	3.561	3.88	4.417	
Late05	36	40	25	29	47	36	4.017	3.751	3.482	3.971	4.404	3.983
Late 06						32						3.327
Post 04	20	31	13	28			2.526	3.437	2.466	2.789		
Post 05	24	33	16	28	33	15	3.707	3.526	3.142	3.628	4.063	2.429
Post 06						18						2.679

of cryptogamic vegetation from diverse sites is required and will add valuable information about the biodiversity and nutrient cycling on these areas.

Faunal diversity

Detailed listing of fauna exclusively of rocky plateaus has not yet been carried out. However, diverse vertebrate and invertebrate taxa have been reported from microhabitats on plateaus. Unlike flora, faunal species have the ability to move away from outcrops in stressful conditions of summer or heavy monsoon and seasonal studies are required to assess the complete faunal diversity. Ground dwelling ants, beetles, spiders, scorpions, grasshoppers, odonata, ground nesting birds, reptiles; small and large mammals are often seen on rocky plateaus (Image 11–14). Raptors including migrant species like Lesser Kestrel (Thakur & Watve 2004) have been commonly seen on and around the rocky plateaus. Tadpole Srimp (*Triops granarius* Lucas), Fairy Shrimp (*Streptocephalus dichotomus* Baird), and Clam Shrimps (*Leptestheriella* spp. Nayar & Nair) have been frequently observed in seasonal rock pools (H. Ghate pers. comm. 2012). Shrimps also show adaptation to extreme climate of rocky plateaus as their eggs remain dormant in ephemeral pond soil till the approach of the monsoon.

The smaller invertebrate fauna commonly use boulders on plateaus for shelter during extreme conditions, while the same are used by lizards such as *Sitana ponteceriana* for display. Malabar Crested Larks have been seen very commonly on the plateaus, foraging, displaying on boulders, and nesting. Frogs spawn in ephemeral pools. Lizards, geckos, skinks (*Hemidactylus* spp., *Sitana ponticeriana*, *Cnemaspis* spp.) and caecilians have been frequently observed on plateaus. However, most of the plateau fauna is not easily visible and often takes shelter under boulders especially during the day, either to avoid the harsh sun or because of vulnerability to predators like raptors (eagles are frequently noted) in the open areas. Laterite plateaus have deep caves beneath which are roosting sites for bats as on Panchgani Tableland and Robber's Cave of Mahabaleshwar. Except some of the herpetofauna, endemism and threat status of fauna has not been critically assessed.

Image 11. Scorpion

Image 12. Ants with eggs

Image 13. Immature Indian Courser *Cursorius coromandelicus*, ground nesting species

Image 14. Gravid *Sitana ponteceriana*

Conservation value of rocky plateaus

High endemism and recent records of many new species in diverse taxa from the rocky plateaus in the study area indicates high conservation significance.

Joshi & Janarthanam (2004) first described lateritic plateaus of Goa as habitats showing rich floral endemism. High endemism in rocky plateau vegetation of Maharashtra has been reported by Watve (2007, 2010) and Lekhak & Yadav (2012). A list of endemic species and varieties (as per the listing by Singh & Karthikeyan 2000) that occur on rocky plateaus has been compiled, based on floristic literature and personal observations from the region (Table 5). The threat status as per regional assessment made by Botanical Survey of India (Mishra & Singh 2001) and those completed as part of IUCN Freshwater Biodiversity Assessments are added. Mapping of distributional ranges of endemic herb species is not available for this region. Hence, it is not possible to identify species "exclusive" to the rocky plateaus. Many recently described plant species may have wider distribution than believed at present.

A detailed analysis of endemism on rocky plateaus can be carried out only after regional endemic lists are revised. Hence the list in the Table 5 should be treated only as an indicative one. So far, 188 endemics species have been recorded from primary and secondary observations on the rocky plateaus in the Western Ghats and the Konkan region. The list of endemics is likely to increase as more sites are surveyed. A large number of endemic species on the rocky plateaus are not exclusive, but widespread in similar open moist and sunny habitats such as stream courses, forest edges, cliffs, shrublands etc. However, it can still be safely concluded that the rocky plateaus do serve as important habitats for a large number of endemic plant species.

High endemism in substrate-specific communities is well known across the world (Mota et al. 2004; Chiarucci 2004; Stevanović et al. 2003; Ojeda et al. 2000; Keener 1983). Burke (2003) has shown that rock outcrops make significant contribution to the local and regional species richness. Von Gaisberg & Stierstorfer (2005) have shown a connection between distribution of endemics and geomorphological and geochronological traits of outcrops on El Hierro island in the Canary Islands archipelago. Endemism on outcrops is in many cases correlated with the regional endemism (Seine et al. 1998). This is also indicated in the present listing as Poaceae species number is highest in the list of endemics and the same is highest in generic endemism in India (Irwin & Narasimhan 2011).

Dimeria, Dichanthium, Glyphochloa, Eriocaulon, Utricularia and *Smithia* include many widely distributed species in the region, but have speciated into narrow endemics with restricted distribution on few rocky plateau localities, e.g., *Dichanthium panchganiensis*, *Ceropegia jainii, Aponogeton satarensis* seen on HLF. Such endemics with restricted distribution are more on high level plateaus as they are separated from each other by deeply weathered areas and function as terrestrial habitat islands especially for species with dispersal limitations. Shukla et al. (2002) have observed a similar manner of speciation in *Isoetes* on the high-altitude plateaus in the Western Ghats and central India. The Konkan ferricretes are more or less continuous without distinct breaks. Hence many endemics such as *Dimeria woodrowii* are widespread in Konkan. However, Konkan plateaus are affected by landuse changes and other biotic pressures, which have caused fragmented populations of species such as *Dipcadi concanense*.

Table 5. Endemic species (as per BSI, Singh & Karthikeyan 2000) reported on rocky plateaus along with threat status and occurrence

Family	Species	Threat status as per BSI	IUCN 2012	Rocky Plateau type	Observation by
1. Acanthaceae	*Justicia trinervia* Vahl			HLF	Watve, A.
2. Acanthaceae	*Lepidagathis lutea* Dalzell			LLF	Watve, A.
3. Acanthaceae	*Lepidagathis mitis* Dalz.			BM	Watve, A.
4. Acanthaceae	*Pleocaulus sessilis*(Nees) Bremek.			HLF, LLF	Watve, A.
5. Alismataceae	*Wiesneria triandra* (Dalz.) Micheli		Least Concern	LLF	Watve, A.
6. Amaryllidaceae	*Pancratium parvum* Dalz.			BM	Watve, A.
7. Apiaceae	*Pimpinella adscendens* Dalz.			HLF, BM	Watve, A.
8. Apiaceae	*Pinda concanensis* (Dalz.) P. K. Mukh. & Constance			HLF, BM	Watve, A.
9. Apocynaceae	*Ceropegia attenuata* Hook.	Vulnerable		LLF	Watve, A.
10. Apocynaceae	*Ceropegia jainii* Ansari & Kulkarni	Critically Endangered		HLF	Watve, A.
11. Apocynaceae	*Ceropegia rollae* Hemadri	Critically Endangered		BM	Mishra & Singh, 2001
12. Apocynaceae	Ceropegia anjanerica Malpure, Kamble & Yadav			BM	Watve, A.
13. Apocynaceae	*Ceropegia media* (H. Huber) Ansari			HLF	Lekhak & Yadav, 2012
14. Apocynaceae	*Ceropegia sahyadrica* Ansari & B. G. Kulk.			HLF	Lekhak & Yadav, 2012
15. Apocynaceae	*Ceropegia vincaefolia* Hook.			HLF, BM	Watve, A.
16. Aponogetonaceae	*Aponogeton satarensis* Sundararaghavan et al.		Endangered	HLF	Watve, A.
17. Aponogetonaceae	*Aponogeton bruggenii* Yadav & Govekar		Vulnerable	LLF	Mishra & Singh, 2001
18. Araceae	*Amorphophallus konkanensis* W.L.A. Hetterscheid, S.R. Yadav & K.S. Patil	Vulnerable		LLF	Mishra & Singh, 2001
19. Araceae	*Arisaema caudatum* Engl.	Endangered		HLF, BM	Watve, A.
20. Araceae	*Arisaema murrayi(J. Graham) Hook.*			HLF, BM	Watve, A.
21. Araceae	*Cryptocoryne cognata* Schott		Endangered	HLF	Watve, A.
22. Araceae	*Cryptocoryne cognatoides* Blatt. & McC.	Critically Endangered		HLF	Watve, A.
23. Araceae	*Arisaema sahyadricum* var. ghaticum Sardesai et al.			HLF	Lekhak & Yadav, 2012
24. Araceae	*Arisaema sahyadricum* S.R.Yadav, S.K. Patil & Bachulkar			HLF	Lekhak & Yadav, 2012
25. Asclepiadaceae	*Brachystelma malwanense* S.R.Yadav & N.P.Singh	Critically Endangered		LLF	Mishra & Singh, 2001
26. Asparagaceae	*Chlorophytum glaucoides* Blatt.			HLF, BM	Lekhak & Yadav, 2012
27. Asparagaceae	*Chlorophytum glaucum* Dalzell			HLF	Lekhak & Yadav, 2012
28. Asteraceae	*Adenoon indicum Dalzell*			HLF	Watve, A.
29. Asteraceae	*Cyathocline lutea* Law ex Wight	Endangered		BM	Watve, A.
30. Asteraceae	*Lamprachaenium microcephalum* (Dalz.) Bth.			HLF, BM	Watve, A.
31. Asteraceae	*Pulicaria angustifolia* DC.			LLF	Watve, A.
32. Asteraceae	*Senecio belgaumensis* C.B.Clarke			HLF BM	Lekhak & Yadav, 2012
33. Asteraceae	*Senecio bombayensis* Balakr.			HLF BM	Watve, A.
34. Asteraceae	*Senecio dalzellii* C.B.Clarke			BM	Watve, A.
35. Asteraceae	*Senecio edgeworthii* Hook. f.			HLF	Watve, A.
36. Asteraceae	*Nanothamnus sericeus* Thoms.			BM	Watve, A.

Family	Species	Threat status as per BSI	IUCN 2012	Rocky Plateau type	Observation by
37. Balsaminaceae	*Impatiens lawii* Hook. f. & Thoms.			HLF	Watve, A.
38. Balsaminaceae	*Impatiens tomentosa* Heyne ex Wight & Arn.			HLF	Watve, A.
39. Balsaminaceae	*Impatiens dalzellii* Hook. f. & Thomson			HLF	Watve, A.
40. Begoniaceae	*Begonia concanensis* A.DC.			HLF, BM	Watve, A.
41. Begoniaceae	*Begonia crenata* Dryand.			HLF, BM	Watve, A.
42. Boraginaceae	*Adelocaryum coelestinum* (Lindl.) Brand			HLF, BM	Watve, A.
43. Boraginaceae	*Adelocaryum malabaricum* (C.B. Clarke) Brand			HLF, BM	Watve, A.
44. Boraginaceae	*Mattiastrum lambertianum* (C.B.Cl.) Brand.			BM, HLF	Watve, A.
45. Commelinaceae	*Cyanotis concanensis* Hassk.			HLF	Watve, A.
46. Commelinaceae	*Cyanotis fasciculata var. glabrescens* C.B. Cl.			HLF	Watve, A.
47. Commelinaceae	*Murdannia lanuginosa* (Wall. ex C.B. Cl.) Brueck.	Endangered		HLF	Watve, A.
48. Commelinaceae	*Murdannia versicolor* Bruckner			HLF	Watve, A.
49. Convolvulaceae	*Ipomoea clarkei* Hook. f.	Endangered		BM	Mishra & Singh, 2001
50. Convolvulaceae	*Merremia rhyncorhiza* (Dalz.) Hall. f.			HLF	Watve, A.
51. Cyperaceae	*Fimbristylis lawiana* (Boeck.) J.Kern		Least Concern	HLF, LLF, BM	Watve, A.
52. Cyperaceae	*Fimbristylis ratnagirica* V.P.Prasad & N.P.Singh	Data Deficient		LLF	Mishra & Singh, 2001
53. Cyperaceae	*Fimbristylis ambavanensis* V.P.Prasad & N.P.Singh			BM	Prasad & Singh, 1999
54. Cyperaceae	*Fimbristylis unispicularis* E.Govindarajalu & K.Hemadri	Critically Endangered		BM	Mishra & Singh, 2001
55. cyperaceae	*Eleocharis wadoodii* S. R. Yadav et al.			HLF	Lekhak & Yadav, 2012
56. Eriocaulaceae	*Eriocaulon conicum* (Fyson) C.E.C.Fisch.			HLF	Kulkarni & Desai (1972)
57. Eriocaulaceae	*Eriocaulon cuspidatum* Dalzell			LLF	Watve, A.
58. Eriocaulaceae	*Eriocaulon dalzellii* Koern.			HLF, LLF	Watve, A.
59. Eriocaulaceae	*Eriocaulon duthiei* Hook.f.			HLF	Kulkarni & Desai (1972)
60. Eriocaulaceae	*Eriocaulon eleanorae* Fyson			HLF	Kulkarni & Desai (1972)
61. Eriocaulaceae	*Eriocaulon epedunculatum* Potdar, Anil Kumar Bis,Otaghvari & Sonkar	New: not assessed		HLF	Watve, A.
62. Eriocaulaceae	*Eriocaulon eurypeplon* Koern.		Least Concern	HLF, LLF	Watve, A.
63. Eriocaulaceae	*Eriocaulon leucomelas* Steud.		Least Concern	LLF	Sharma et al. 1996
64. Eriocaulaceae	*Eriocaulon minutum* Hook.f.		Least Concern	HLF, BM	Watve, A.
65. Eriocaulaceae	*Eriocaulon ratnagiricum* Yadav, Gaikwad & Sardesai		Critically Endangered	LLF	Mishra & Singh, 2001
66. Eriocaulaceae	*Eriocaulon santapaui* Moldenke		Critically Endangered	BM	Mishra & Singh, 2001
67. Eriocaulaceae	*Eriocaulon sedgwickii* Fyson		Least Concern	HLF	Watve, A.
68. Eriocaulaceae	*Eriocaulon stellulatum* Koern.		Least Concern	HLF, BM, LLF	Watve, A.
69. Eriocaulaceae	*Eriocaulon tuberiferum* Kulkarni & Desai		Vulnerable	HLF	Watve, A.
70. Eriocaulaceae	*Euphorbia notoptera* Boiss.			LLF	Watve, A.
71. Eriocaulaceae	*Eriocaulon apetalum* Punekar, Malpure & Lakshmin.			HLF	Lekhak & Yadav, 2012
72. Euphorbiaceae	*Euphorbia concanensis* Janarthanam & Yadav	Critically Endangered		LLF	Watve, A.

Family	Species	Threat status as per BSI	IUCN 2012	Rocky Plateau type	Observation by
73. Euphorbiaceae	*Euphorbia khandalensis* Blatt. & Hallb.	Endangered		BM	Watve, A.
74. Euphorbiaceae	*Euphorbia panchganiensis* Blatt. & McCann	Endangered		HLF	Watve, A.
75. Fabaceae	*Alysicarpus belgaumensis* Wight			HLF	Watve, A.
76. Fabaceae	*Crotalaria filipes* Benth.			HLF, BM, LLF	Watve, A.
77. Fabaceae	*Crotalaria vestita* Baker			HLF, BM, LLF	Watve, A.
78. Fabaceae	*Flemingia gracilis* (Mukerjee) Ali	Endangered		BM	Mishra & Singh, 2001
79. Fabaceae	*Flemingia nilgiriensis Wight ex Cooke*	Endangered		HLF	Watve, A.
80. Fabaceae	*Geissaspis tenella* Benth.			HLF, BM, LLF	Watve, A.
81. Fabaceae	*Indigofera dalzellii* T. Cooke			HLF, BM, LLF	Watve, A.
82. Fabaceae	*Smithia agharkarii* Hem.	Vulnerable		HLF, BM	Watve, A.
83. Fabaceae	*Smithia bigemina* Dalz.			HLF, BM, LLF	Watve, A.
84. Fabaceae	*Smithia hirsuta* Dalz.			HLF, BM, LLF	Watve, A.
85. Fabaceae	*Smithia purpurea* Hook.			BM	Watve, A.
86. Fabaceae	*Smithia pycnantha* Benth. ex Baker			HLF, BM	Watve, A.
87. Fabaceae	*Smithia salsuginea* Hance			HLF LLF BM	Watve, A.
88. Fabaceae	*Smithia setulosa* Dalz.			HLF LLF BM	Watve, A.
89. Fabaceae	*Vigna khandalensis* (Santapau) Raghavan & Wadhwa			HLF, BM, LLF	Watve, A.
90. Fabaceae	*Desmodiastrum belgaumense* (Wight) A. Pramanik & Thoth.			HLF	Lekhak & Yadav, 2012
91. Gentianaceae	*Exacum lawii* C. B. Cl.			HLF, BM	Watve, A.
92. Gentianaceae	*Swertia densifolia* (Griseb.) Kashyapa			HLF	Watve, A.
93. Gentianaceae	*Swertia minor* (Griseb.) Knobl.			HLF	Watve, A.
94. Hydatellaceae	*Trithuria konkanensis* S.R.Yadav & Janarth.			LLF	Watve, A.
95. Isoetaceae	*Isoetes dixitii* Shende			HLF	Watve, A.
96. Isoetaceae	*Isoetes sahyadriensis* Mahabale			HLF	Shukla et al. 2002
97. Isoetaceae	*Isoetes panchganiensis* G.K. Srivast., D.D. Pant & P.K. Shukla var. panchganiensis		Endangered	HLF	Shukla et al. 2002
98. Lamiaceae	*Pogostemon deccanensis* (Panigr.) Press			HLF, LLF, BM	Watve, A.
99. Lentibulariaceae	*Utricularia albocaerulea* Dalz.		Vulnerable	HLF, LLF	Watve, A.
100. Lentibulariaceae	*Utricularia lazulina* P.Taylor		Least Concern	LLF	Watve, A.
101. Lentibulariaceae	*Utricularia praeterita* P. Taylor		Near Threatened	HLF, BM	Watve, A.
102. Lentibulariaceae	*Utricularia purpurascens* Grah.			HLF, BM	Watve, A.
103. Liliaceae	*Camptorrhiza indica* S.R.Yadav, N.P.Singh & B.Mathew	Critically Endangered		LLF	Mishra & Singh, 2001
104. Liliaceae	*Dipcadi concanense* Baker	Critically Endangered		LLF	Watve, A.
105. Liliaceae	*Dipcadi maharashtrense* Deb & S.Dasgupta	Critically Endangered		HLF	Mishra & Singh, 2001
106. Liliaceae	*Dipcadi saxorum* Blatt.	Critically Endangered		LLF	Mishra & Singh, 2001
107. Liliaceae	*Dipcadi ursulae var. ursulae* Blatt.	Endangered		HLF, BM	Mishra & Singh, 2001
108. Liliaceae	*Iphigenia magnifica* M.Y.Ansari & R.S.Rao	Vulnerable		HLF	Watve, A.
109. Liliaceae	*Iphigenia stellata* Blatt.	Vulnerable		HLF	Watve, A.

Family	Species	Threat status as per BSI	IUCN 2012	Rocky Plateau type	Observation by
110. Liliaceae	*Chlorophytum gothanense* Malpure & S.R.Yadav	New: not assessed		HLF	Lekhak & Yadav, 2012
111. Lythraceae	*Rotala floribunda* Koehne	Endangered		CLIFFS	Watve, A.
112. Lythraceae	*Rotala malampuzhensis* Nair ex C.D.K. Cook		Least Concern	HLF, LLF	Watve, A.
113. Lythraceae	*Rotala ritchiei* Koehne			HLF	Watve, A.
114. Malvaceae	*Decaschistia trilobata* Wight			HLF	Watve, A.
115. Melastomataceae	*Sonerila scapigera* Dalzell			HLF, BM	Watve, A.
116. Orchidaceae	*Bulbophyllum fimbriatum* H.Perrier			HLF, BM	Watve, A.
117. Orchidaceae	*Dendrobium barbatulum* Lindl.			HLF, BM, LLF	Watve, A.
118. Orchidaceae	*Habenaria crassifolia* A. Rich.			HLF, BM, LLF	Watve, A.
119. Orchidaceae	*Habenaria grandifloriformis* Blatt. & McC.			HLF, BM, LLF	Watve, A.
120. Orchidaceae	*Habenaria heyneana* Lindl.			HLF, BM, LLF	Watve, A.
121. Orchidaceae	*Habenaria panchganiensis* Sant. & Kap.	Critically Endangered		HLF, BM	Watve, A.
122. Orchidaceae	*Habenaria rariflora* A. Rich.			HLF, BM	Watve, A.
123. Orchidaceae	*Peristylus stocksii* (Hook.f.) Kranzl.			HLF	Watve, A.
124. Orchidaceae	*Aerides maculosa* Lindl.			HLF, BM	Watve, A.
125. Orchidaceae	*Dendrobium microbulbon* A. Rich.			HLF	Watve, A.
126. Poaceae	*Arthraxon jubatus* Hack.			HLF, BM	Watve, A.
127. Poaceae	*Arthraxon junnarensis* Jain & Hemadri	Endangered		HLF, BM	Mishra & Singh, 2001
128. Poaceae	*Arthraxon lanceolatus* Hochst.			HLF	Watve, A.
129. Poaceae	*Arthraxon meeboldi* Stapf			HLF	Watve, A.
130. Poaceae	*Arundinella ciliata* Nees ex Miq.			HLF, BM	Watve, A.
131. Poaceae	*Arundinella metzii* Hochst. ex Miq.			HLF, BM	Watve, A.
132. Poaceae	*Arundinella spicata* Dalz.	Vulnerable		HLF, BM	Watve, A.
133. Poaceae	*Bhidea burnsiana* Bor	Endangered		BM	Watve, A.
134. Poaceae	*Chrysopogon castaneus* Veldkamp & C.B.Salunkhe	Endangered		HLF	Mishra & Singh, 2001
135. Poaceae	*Coelachne minuta* Bor.	Endangered		HLF	Watve, A.
136. Poaceae	*Danthonidium gammiei* (Bhide) C.E.Hubb.			LLF	Watve, A.
137. Poaceae	*Dichanthium armatum* Blatt. & McCann	Vulnerable		BM	Hemadri, 1980
138. Poaceae	*Dichanthium concanensis* (Hook.f.) S.K.Jain & Deshp.			HLF, BM	Blatter & McCann 1928
139. Poaceae	*Dichanthium jainii* (Deshp. & Hemadri) Deshp.	Endangered		BM	Mishra & Singh, 2001
140. Poaceae	*Dichanthium maccannii* Blatt.	data deficient		HLF, BM	Mishra & Singh, 2001
141. Poaceae	*Dichanthium oliganthum* (Hochst. ex Steud.) Cope			HLF	Watve, A.
142. Poaceae	*Dichanthium panchganiense* Blatt. & McCann	Endangered		HLF, BM	Watve, A.
143. Poaceae	*Dimeria blatteri* Bor	Vulnerable		HLF LLF BM	Watve, A.
144. Poaceae	*Dimeria hohenackeri* Hochst. ex Miq.			HLF LLF	Watve, A.
145. Poaceae	*Dimeria ornithopoda var. megalantha* Bor			HLF	Bole & Almeida 1987
146. Poaceae	*Dimeria stapfiana* C.E. Hubb. ex Pilger			HLF	Watve, A.
147. Poaceae	*Dimeria woodrowii* Stapf			LLF	Watve, A.
148. Poaceae	*Eulalia shrirangii* Salunkhe & Potdar	New: not assessed		HLF	Watve, A.

Family	Species	Threat status as per BSI	IUCN 2012	Rocky Plateau type	Observation by
149. Poaceae	*Glyphochloa acuminata* (Hack.) W.D. Clayton var. *acuminata*			LLF	Sharma et al. 1996
150. Poaceae	*Glyphochloa acuminata var. stocksii* (Hook.f.) W.D. Clayton			LLF	Sharma et al. 1996
151. Poaceae	*Glyphochloa acuminata var. woodrowii* (Bor) W.D. Clayton			LLF	Sharma et al. 1996
152. Poaceae	*Glyphochloa divergens var. divergens* (Hack.) W.D. Clayton			HLF	Bole & Almeida 1987
153. Poaceae	*Glyphochloa forficulata* (C.E.C. Fisch.) W.D. Clayton			HLF	Watve, A.
154. Poaceae	*Glyphochloa mysorensis* (Jain & Hemadri) Clayton	Endangered		HLF	Lekhak & Yadav, 2012
155. Poaceae	*Glyphochloa ratnagirica* (Kulk. & Hemadri) Clayton	Endangered		LLF	Watve, A.
156. Poaceae	*Glyphochloa santapaui* (Jain & Desh.) Clayton	Endangered		LLF	Sharma et al. 1996
157. Poaceae	*Glyphochloa talbotii* (Hook.f.) Clayton			LLF	Almeida 1990
158. Poaceae	*Indopoa paupercula* (Stapf) Bor			HLF, BM	Watve, A.
159. Poaceae	*Isachne bicolor* Naik & Patunkar	Endangered		HLF, BM	Watve, A.
160. Poaceae	*Isachne borii* Hemadri	Endangered		BM	Hemadri, 1980
161. Poaceae	*Isachne elegans* Dalzell ex Hook.f.			BM	Hemadri, 1980
162. Poaceae	*Isachne gracilis* C.E.Hubb.			BM	Hemadri, 1980
163. Poaceae	*Isachne lisboae* Hook.f.	Endangered		HLF	Watve, A.
164. Poaceae	*Ischaemum diplopogon* Hook.f.			HLF BM	Watve, A.
165. Poaceae	*Ischaemum impressum* Hack.			BM	Hemadri, 1980
166. Poaceae	*Ischaemum molle* Hook.f.			HLF LLF BM	Blatter & McCann 1935
167. Poaceae	*Ischaemum raizadae* Hemadri & Billore	Vulnerable		HLF BM	Sharma et al. 1996
168. Poaceae	*Ischaemum santapaui* Bor			LLF, BM	Mishra & Singh, 2001
169. Poaceae	*Ischaemum tumidum* Stapf ex Bor			HLF LLF BM	Sharma et al. 1996
170. Poaceae	*Paspalum canarae var. fimbriatum* (Bor) Veldk.			HLF, LLF, BM	Watve, A.
171. Poaceae	*Pseudanthistiria heteroclita*(Roxb.) Hook.f.			HLF, BM	Watve, A.
172. Poaceae	*Pseudodichanthium serrfalcoides* (T. Cooke & Stapf) Bor	Vulnerable		HLF	Watve, A.
173. Poaceae	*Dichanthium paranjpyeanum* (Bhide) Clayton	Endangered		HLF, BM	Watve, A.
174. Poaceae	*Tripogon capillatus* Jaub. & Spach			HLF, BM	Watve, A.
175. Poaceae	*Tripogon jacquemontii* Stapf			HLF, BM, LLF	Watve, A.
176. Poaceae	*Tripogon lisboae* Stapf			HLF, BM	Watve, A.
177. Poaceae	*Jansenella neglecta* S.R. Yadav et al.	New: not assessed		HLF	Lekhak & Yadav, 2012
178. Poaceae	*Arundinella leptochloa* (Nees ex Steud.) Hook. f.			HLF	Lekhak & Yadav, 2012
179. Poaceae	*Glyphochloa maharashtraensis* Potdar & S. R. Yadav			HLF	Lekhak & Yadav, 2012
180. Poaceae	*Isachne swaminathanii* V. Prakash & S. K. Jain			HLF	Lekhak & Yadav, 2012
181. Poaceae	*Mneisethea veldkampii* Potdar et al.			HLF	Lekhak & Yadav, 2012
182. Poaceae	*Pogonachne racemosa* Bor			HLF	Lekhak & Yadav, 2012
183. Rubiaceae	*Oldenlandia stocksii* Hook. f.			HLF, BM	Watve, A.
184. Rubiaceae	*Neanotis lancifolia* (Hook. f.) W. H. Lewis			HLF, LLF	Watve, A.
185. Rubiaceae	*Neanotis montholoni* (Hook. f.) W. H. Lewis			HLF, LLF, BM	Watve, A.
186. Scrophulariaceae	*Rhamphicarpa longiflora* (Arn.) Bth.			HLF, BM, LLF	Watve, A.
187. Zingiberaceae	*Hitchenia caulina* Baker	Vulnerable		HLF	Watve, A.
188. Zingiberaceae	*Curcuma neilgherrensis* Wight			HLF	Lekhak & Yadav, 2012

Mishra & Singh (2001) and Lekhak & Yadav (2012) have assessed many angiosperm endemics as Critically Endangered, Endangered, Vulnerable or Near Threatened using IUCN Red List Categories and Criteria Version 3.1 (IUCN, 2001), though a complete global assessment has not been made so far. This indicates urgent need of a threat assessment of the rocky plateau habitats to identify priorities for conservation of species.

During the IUCN Freshwater Biodiversity Assessment, (Molur et al. 2011), some species including *Aponogeton satarensis, Eriocaulon tuberiferum, Wiesneria triandra,Utricularia* spp. that occur in seasonal pools and EFV on rock outcrops were globally assessed, of which two were included in Critically Endangered, three in Endangered and three in Vulnerable category. *Aponogeton satarensis*, was assessed Endangered (IUCN 2011) based on restricted distribution and current threats. Widespread species such as *Wiesneria triandra,* were assessed Least Concern (IUCN 2011), as they can easily colonize secondary habitats such as rice fields which have waterlogged conditions similar to its primary habitats.

In recent years, new species of *Chlorophytum, Eriocaulon, Mnesithea, Isoetes, Rotala* etc. have been described from rocky plateaus. Surveys of adjacent areas need to be conducted to record the distributional ranges of these species. Kruckberg (2002) had shown that local diversification of plant life is typical for landscapes dominated by geomorphological irregularities at a scale of 10^{-2}-10km^2. Thus even the smallest of the rocky plateaus are extremely significant for local plant diversity and need immediate protection.

The trend of high endemism and restricted distribution seen in plants, is also seen in case of fauna. Abundance of endemic *Hemidactylus albofasciatus,* (Grandison & Soman 1963; Gaikwad et al. 2009) on LLF, and caecilians *Gegeneophis seshachari* (Gower et al. 2007), *Indotyphlus maharashtraensis* from HLF (Giri et al. 2004), recent description of *Hemidactylus satarensis* (Giri & Bauer 2008) from Satara plateau and *Xanthophryne tigrinus* from Amboli region (Biju et al. 2009) indicates that local speciation on rocky plateaus is also seen in herpetofauna. It is also extremely necessary to take up listing and distribution studies of invertebrate fauna to analyze if similar trend is observed in other taxa.

Presence of endemic flora and fauna, presence of habitat specific plants as well as animals and many descriptions of new localized species clearly indicate a high conservation value for the habitat. The HLF, LLF and BM each have characteristic endemic plants and animals which are exclusive to them. Hence, conservation of representative areas of each type of rocky plateaus needs to be planned.

Humans and rocky plateaus

People form an integral part of most rock outcrop landscapes across the world. In the study area, local people have specific names such as "Sada" for lateritic plateau and "Katal" for basalt outcrops. The presence of temples on most rocky areas and associated legends indicate that these are well-known features in the landscape. Dhangars (=shepherds) of Satara District use the rocky plateau habitats for grazing of livestock. On Jagmin Plateau in Satara District local community has a practice of leaving boulders in mound at one place in memory of the dead. Every year on certain date a ritual is performed there and offerings placed. Many large plateaus have a temple of the local deity e.g. Masai, Mhavashi, Patan, Durgawadi rocky plateaus. Some of them are locally well known and attract large number of people at festival times.

Ecosystem services

Owing to the hard impermeable rock surface, rocky plateaus serve as water catchments. The lithomarge allows water drainage from underground channels and perennial springs are commonly seen along the plateaus. Mass blooming of the plants on the rocky plateaus offers abundant food supply for the pollinators, which is important for crops and orchards in surrounding area. It is necessary to further evaluate ecosystem services of the plateau such as nutrient cycling etc.

Impact of biotic pressures

The entire Western Ghats and Konkan region is under heavy biotic pressures and rocky plateaus are no exception. Grazing, trampling, conversion to agriculture, quarrying have been going on for several years. Agriculture, tourism, windmill farms, mining and more recent land use changes have taken a heavy toll on the rocky plateaus habitats.

(i) Grazing, trampling, fire: Grazing by cattle, trampling and fire are common on all plateaus easily accessible to people except in remote plateaus of Sahyadri Tiger Reserve. The plateaus are tolerant to low amount of grazing, as even wild herbivores such as hares, Barking Deer, Sambar and Gaur regularly graze on the plateaus. However, increase in grazing pressure can directly affect some sensitive biodiversity and further studies are required. Putting fire to the vegetation on plateaus is a regular feature on Kas and Zenda plateaus. It is not a natural phenomenon and mostly done by careless tourists and poachers. This causes destruction of fauna and affects seed banks in the shallow soil which are necessary for future growth of vegetation. It may affect the characteristic plant communities in future.

(ii) Agriculture, ponds and plantation: Agriculture on large scale is not possible on the rocky plateaus. However, in recent years, government schemes for reclamation of wastelands for cultivation have affected some plateau areas in Pune District. Schemes of water storage and water conservation, leading to digging of ponds, bunding, bund plantation of exotic trees have all caused many changes to the high- altitude plateau flora. Some plantations of bamboo and *Acacia auriculiformis* were made by the forest department on plateaus in Satara District. These species either do not survive or remain stunted owing to the harsh climate here. But trenching and digging for the plantations damages the natural microhabitats (Image 15).

Image 15. Water conservation efforts on the rocky plateau leading to habitat conversion

Conversion of plateaus into mango orchards has led to the degradation of many rocky plateaus in Ratnagiri and Sindhudurg districts.

(iii) Quarrying: This has had the largest impact on the entire Konkan (low-level laterite) areas. The deep layers of laterite are extensively quarried and the bricks (= chira/jambha) used for construction locally, and increasingly in areas as far away as Pune and Mumbai. Quarrying is rampant and a major source of destruction of Konkan laterite (Image 16).

Image 16. Quarrying of laterite blocks in Konkan

(iv) Wind farms: The rocky plateaus near Chalkewadi, Boposhi, Jagmin, Patan (all in the Satara District) are entirely taken up by windmill farms of high intensity (Image 17). The wind farms are present on private lands but are adjacent to the forest lands of Koyna and Chandoli Wildlife Sanctuary within Sahyadri TR. The presence of windmills has led to construction of roads and buildings which now divide the large plateau into many sectors. The rubble of the construction is thrown on the plateau. The digging and construction have disturbed the drainage pattern on the outcrops leading to disturbance of natural microhabitats. Increased disturbance encourages entry of invasive species, exotic as well as indigenous, from surrounding scrub areas, which can colonize the new habitats. *Senecio bombayensis* and *Blumea oxyodonta*, species which belong to the scrub areas and are thus alien to the plateau microhabitats, are now seen growing on rubble heaps between the windmills and along the roads.

Although the number of localities showing windfarms is small, some of the largest plateaus at high altitude, Chalkewadi and Mhavashi, Boposhi are entirely taken up by windfarms. Many new areas are proposed for development, even at the cost of RF lands. Pande et al. (2013) have assessed bird collision risk in a windfarm and recommended that EIA should be made mandatory for windfarms in Western Ghats.

(v) Tourism: Heavy tourism has destroyed the natural diversity of Panchgani Tableland and the same threat is posed to the Kas Plateau, recently declared as World Heritage Site. The destructive activities on Panchgani Tableland such as horse riding, vehicle driving have been banned by the High Court. Although this tableland is part of Mahabaleshwar-Panchgani Ecosensitive Zone and a declared conservation zone and natural heritage site, its biodiversity has not received any special protection. Kas is an area of reserved forest, where forest department is trying to regulate tourism in an effort to make it sustainable. However, one needs to first study tourist carrying capacity and tourism impact on such sensitive habitats (Image 18).

(vi) Mining: Mining is the most harmful of anthropogenic activities on the rocky plateaus. High

Image 17. Windmills and associated infrastructure leading to slow degradation of the microhabitats

Image 18. Disturbance due to excessive trampling: viewing point trampled by tourists, bare of any natural vegetation

level lateritic plateaus have deposits of aluminium ore bauxite underneath the hard surface. Lad & Samant (2009) have documented the environmental and social impacts of mining in region. The Kolhapur plateaus are well known for high quality bauxite and many have been mined for more than 20 years. At present, only the rocky plateaus within the Sahyadri TR are protected from bauxite mining.

(vii) Developmental projects: Of the diverse rocky plateaus studied, those in Konkan (LLF) are at most risk, as none of them falls under any legal protected area. These vast and biologically rich plateaus have been claimed for nuclear power plant, conversion of land into intensive urbanization and industrialization. The land conversion is very easy because the rocky plateaus fall under 'wasteland' category. Jaitapur nuclear power plant, Ratnagiri airport, Ratnagiri MIDC, Devrukh township are some examples of development on Konkan plateaus. The sad neglect of such a specialized habitat and its biodiversity needs to be stopped immediately.

(viii) Invasive species: The species that grow on rocky plateaus are adapted to the extreme physico-chemical and climatic conditions of this habitat and have a competitive advantage over other species of more mesic environments. However, activities that disturb the sensitive balance lead to invasion by generalists from surrounding, either indigenous or non-indigenous, species. This is already seen on some rocky plateaus which have been exposed to prolonged disturbance such as Panchgani Tableland. Building a road, digging pits for windmills, plantation lead to soil upheaval. Debris dumping allows establishment of *Senecio* spp*. Heteropogon contortus, Cynodon dactylon* from surrounding scrub grassland. On some plateaus, around ponds, hardy weeds such as *Argemone mexicana* have established. Influx of tourists on large scale has led to accidental intrusion of invasives from faraway areas, garden weeds (*Tridax procumbens, Synedrella nodiflora* etc.) on the Panchgani Plateau. Invasives compete with the specialist vegetation of similar herbaceous nature. This is one of the most serious threats to the special biodiversity.

The impacts discussed above indicate the nature and diversity of threats to the rocky plateaus in study area. Immediate steps need to be taken for conservation and management.

CONSERVATION ACTION

As seen from the discussion above, most rocky plateau sites are facing threats except those in protected areas. Thus only a limited spectrum of biodiversity of the lateritic plateaus is under legal protection. It is necessary to take immediate conservation action to protect less disturbed rocky plateaus representative of the three types (LLF, HLF and BM) and also for specific rare and threatened species.

The biotic pressure varies from low impact with slow degeneration of species population such as by trampling to high impact with total destruction of the habitat and its diversity as in case of mining.

As emphasized above in the discussion, many more exploratory and experimental scientific studies are required to aid the conservation planning. However, the processes such as land conversion are happening at such a fast rate that scientific studies may not be completed before the decisions of conversion are made. Hence, in addition to the scientific studies, simultaneous actions for conserving known sites of high diversity are necessary.

Suggested conservation actions are:

A. Conservation of habitat: Areas of high conservation significance which are currently under threat need to be identified and immediate measures have to be taken for conservation of the habitat. CEPF-ATREE funded small grant project "Networking and Information Support for Rocky Plateau Conservation in Sahyadri-Konkan corridor" was initiated based on this view. It attempts to identify and strengthen ongoing conservation and restoration projects on 15 rocky plateau sites across the NW Ghats. The aim is to link scientific documentation with conservation planning, which will ultimately help in protecting the sites.

B. Conservation of species: Another approach is to identify areas occupied by highly threatened taxa or those with restricted distribution and accord legal protection for in situ conservation of the species. At present the threatened species of plants and animals and their habitats are not protected under any special legal status. Thus it is impossible to take legal action against destruction of habitats or populations of threatened species.

All the available scientific data indicates that the rocky plateaus function as terrestrial habitat islands. Therefore it is necessary to protect a large number of sites throughout the distributional range of the habitat if a significant percentage of rock outcrop biodiversity is to be protected. It will be impossible to include all or even a few in a single protected area. However, considering the importance of the habitat, as many sites as possible need to be protected.

Some specific suggestions are:

1. For rocky plateaus under ownership of forest department

- Extra protection to be given against mining or conversion to wind farms, grazing, fires, heavy tourism, and monitoring for indirect threats.

- Managing the plateaus in Reserve Forest and ecosensitive areas for conservation of biodiversity and ecology. Regulation of landscape changes such as plantations, construction of bunds, ponds, tourism, by scientific methods. Involving local communities in conservation, monitoring, sensitization towards ecosystem services.

- Additional protection to surrounding private lands to help in conservation.

2. For rocky plateaus not under the ownership of forest department

- Identify level of protection required. Sanctuary notification is very difficult at present if they are not already forest lands. Acquiring of revenue, private lands, designation of other conservation categories such as conservation zones can be considered and management guidelines can be formed for appropriate protection.

- Discouraging quarrying, mining, power plants by conducting thorough impact assessments and declaring the areas biodiversity rich and hence "no-go" for large scale development.

- Assess feasibility of cluster sanctuary especially for the Konkan plateaus, which have residual patches due to fragmentation of habitats.

3. Create awareness and build capacity at all levels

- For scientists, who can contribute towards scientific understanding of the habitat,

- For society, for monitoring the habitats, forming pressure group for conservation, responsible tourism,

- For local community, for local management, conservation benefit sharing, reducing impacts by providing alternative housing material, controlled grazing, controlled agriculture,

- For Policy makers, for developing specific policy recommendations for better protection of the rocky plateaus and also of other rock outcrops.

Management actions

The nature of biodiversity of the rocky plateaus and the habitat is different from forest or grassland habitats. The biodiversity of the rocky plateaus has evolved and specially adapted to phosphate poor azonal soils with seasonal extremes of water availability. These conditions are formed as a result of natural processes of weathering over millions of years. The nutrients and water need to continuously seep through the different habitats, maintaining a flow of nutrients across the microhabitats for allowing the natural plant and dependent animal communities to develop. Introducing artificial blockages in the flow of nutrients and water will result in altering the ecosystem processes (Image 14) and ultimately change the vegetation, by allowing easy establishment of grasses, shrubs and trees from surrounding scrub areas such that it will eventually compete with the specialized endemic flora. Hence, it is necessary to understand that typical habitat management practices such as soil and water conservation should not be practiced for this habitat.

Fire is not a natural part of this habitat, and leads to burning of already scarce biomass, lichen and moss flora important in nutrient fixing and alters the ecosystem at the same time affecting fauna. Hence, it should be prevented. Although grazing by domestic cattle on low scale does not appear to be harmful to the habitat, studies are required to see to what extent it can be allowed at each site, as the cattle competes with the wild herbivores.

Removal of plants and animals species, natural to the habitat should be prohibited. To protect diverse plant communities, care should be taken to maintain the entire range of microhabitats described in this paper. Removal of boulders, filling of shallow ponds, or altering the drainage pattern can have severe impacts on biodiversity which may be visible only after some years.

Tourism, wind farms, infrastructure development and mining are serious threats to the rocky plateaus. Unfortunately, ecological impact assessment (EIA) is not mandatory except for mining in the region. But considering the sensitive nature of the biodiversity of the rocky plateaus, comprehensive EIA should be made mandatory for any development affecting the area which should include extensive studies in monsoon season.

Recommendations

Following recommendations can be made based on above:

- Exclusion from the wasteland or Barren Rock Category

- Scientific enumeration of the floral and faunal richness of the habitat including those in the PAs as well as non PAs with special focus on lesser-known cryptogamic vegetation and invertebrate fauna

- Exploring plant-animal relationships on rocky plateaus (e.g., pollination)

- Global threat assessment of the endemic elements as well as other species at local level. Compilation of distributional data of endemic herb species for understanding their dependence on rocky plateau localities.

- Establishment of experimental research projects to understand rocky plateau ecology, ecosystem processes, services, and linkages

- Monitoring the rocky plateau ecology on long-term basis

- Assessment of ecological status of the rocky plateaus and biodiversity

- Enhanced protection of rocky plateaus within existing protected areas and protection of additional representative sites to complement currently protected sites

- Involving local communities in conservation and monitoring exercises

- Limiting destructive activities such as mining, plantation, tourism, constructions and burning on plateaus

- Awareness generation about the importance of preserving these habitats in scientists, policy makers and society

It is hoped that this approach will prove to be a step towards a much more comprehensive study of the biodiversity of rock outcrops in entire India and will sensitize policy makers to design conservation strategies for this unique habitat type.

REFERENCES

Almeida, S.M. (1990). Flora of Sawantwadi. *Journal of Economic and Taxonomic Botany Additional Series* 2: 715pp.

Bachulkar, M. (1983). Endangered endemic taxa of Satara District, Maharashtra. *Rayat Research Journal* 1: 109–115.

Bharucha, F.R. & M.Y. Ansari (1963). Studies on plant association of slopes and screes of Western Ghats, India. *Vegetatio* 11: 141–154.

Biju, S.D., I. Van Bocxlaer, V.B. Giri, S.P. Loader & F. Bossuyt (2009). Two new endemic genera and a new species of toad (Anura: Bufonidae) from the Western Ghats of India. *BMC Research Notes* 2: 241

Blatter, E. & C. McCann (1928). Revision of the flora of Bombay Presidency: Graminae. *Journal of the Bombay Natural History Society* 32: 408–435.

Blatter, E. & C. McCann (1935). *The Bombay Grasses*. Scientific Monograph No. 5., Imperial Council for Agricultural Research India, New Delhi, xxi+324pp.

Bole, P.V. & M.R. Almeida (1987). Materials for the flora of Mahabaleshwar - 8. *Journal of the Bombay Natural History Society* 84: 372–391.

Burbanck, M.P. & R.B. Platt (1964). Granite outcrop communities of the Piedmont plateau in Georgia. *Ecology* 45: 292–306.

Burke, A. (2003). The role of inselbergs in contributing to local and regional plant species richness. *Biodiversity and Conservation* 12: 469–486.

Chavan, P.V. Khandekar & S. Mahamulkar (1973). The flora of Kas -area from Satara district, Maharashtra, India. *M.V.M. Patrika* 8: 3–15.

Chiarucci, A. (2004). Vegetation ecology and conservation on Tuscan Ultramafic soils. *Botanical Review* 69: 252–268.

Deshpande, S., B.D. Sharma & M.P. Nayar (1993). *Flora of Mahabaleshwar and Adjoining Areas, Maharashtra. Flora of India Series 3—Vol. 1*. Botanical Survey of India, Calcutta, 431pp.

Deshpande, S., B.D. Sharma & M.P. Nayar (1995). *Flora of Mahabaleshwar and Adjoining Areas, Maharashtra. Flora of India Series 3—Vol. 2*. Botanical Survey of India, Calcutta, 433–776pp.

Diddee, J., S.R. Jog, V.S. Kale & V.S. Datye (2002) (eds.). *Geography of Maharashtra*. Rawat Publications, Jaipur & New Delhi, 364pp.

Dörrstock, S., S. Porembski & W. Barthlott (1996). Ephemeral flush vegetation on inselbergs in the Ivory Coast (West Africa). *Candollea* 51: 407–419.

Gaikwad, K.S., H. Kulkarni, R. Bhambure & V. Giri (2009). Notes on the distribution, Natural history, and variation of *Hemidactylus albofasciatus* (Grandison and Soman, 1963) (Squamata: Gekkonidae). *Journal of the Bombay Natural History Society* 106(3): 305–312.

Ghate, U., S. Bhagwat, Y. Gokhale & V.G. Broome (1997). Assessing the tropical forest plant diversity: A case study from the Western Ghats, India. *International Journal of Ecology and Environmental Sciences* 23: 419–444.

Giri, V.B. & A.M. Bauer (2008). A new ground-dwelling *Hemidactylus* (Squamata: Gekkonidae) from Maharashtra, with a key to the *Hemidactylus* of India. *Zootaxa* 1700: 21–34.

Giri, V.B., D.J. Gower & M. Wilkinson (2004). A new species of *Indotyphlus* Taylor (Amphibia: Gymnophiona: Caeciliidae) from the Western Ghats, India. *Zootaxa* 739: 1–19.

Gower, D.J., V. Giri & M. Wilkinson (2007). Rediscovery of *Gegeneophis* *seshachari* Ravichanddran, Gower & Wilkinson, 2003 Amphibia: Gymnophiona: Caeciliidae) at the type locality. *Herpetozoa* 19(3/4): 121–127.

Grandison, A.C. & P.W. Soman (1963). Description of a new geckonid lizard from Maharashtra, India. *Journal of the Bombay Natural History Society* 60: 322–325.

Gunnell, Y. (2001). Morphology and scarp recession rates of the Western Ghats escarpment, pp. 89–117. In: Gunnell, Y. & B.P. Radhakrishna (eds.). *Sahyadri - The Great Escarpment of the Indian Subcontinent Patterns of Landscape Development in the Western Ghats).* Geological Society of India, Bangalore 1: 717.

Gunnell, Y. & B.P. Radhakrishna (2001) (eds.). Sahyadri - *The Great Escarpment of the Indian Subcontinent (Patterns of Landscape Development in the Western Ghats).* Geological Society of India, Bangalore, 1: 717pp, 2: 336pp.

Hemadri, K. (1980). *Grasses of Junnar and its surroundings, Pune District (Maharashtra state).* Bishen Singh Mahendra Pal Singh, Dehradun.

Irwin, S.J. & D. Narasimhan (2011). Endemic genera of Angiosperms in India: A Review. *Rheedea* 21(1): 87–105.

IUCN (2012). IUCN Red List of Threatened Species. Version 2012.2. <www.iucnredlist.org>

Jacobi, C.M., F.F. do Carmo, R.C. Vincent & J.R. Stehmann (2007). Plant communities on ironstone outcrops: a diverse and endangered Brazilian ecosystem. *Biodiversity & Conservation* 16: 2185–2200.

Jog, S.R., A. Wakhare, S. Chaudhuri, M. Unde & S.D. Pardeshi (2002). Maharashtra landscape: A perspective, pp. 19–57. In: Diddee, J., S.R. Jog, V.S. Kale & V.S. Datye (eds.). *Geography of Maharashtra*. Rawat Publications, Jaipur & New Delhi, 364pp.

Joshi, V.C. & M.K. Janarthanam (2004). The diversity of life-form type, habitat preference and phenology of the endemics in the Goa region of the Western Ghats, India. *Journal of Biogeography* 31: 1227–1237.

Keener, C.S. (1983). Distribution and biohistory of endemic flora of Mid-Appalachian shale Barrens. *Botanical Review* 49: 65–115.

Krieger, A., S. Porembski & W. Barthlott (2000). Vegetation of seasonal rock pools on Inselbergs situated in the savanna zone of the Ivory Coast (West Africa). *Flora* 195: 257–266.

Kruckberg, A.R. (2002). *Geology and Plant Life: The Effects of Landforms and Rock types on plants*. University of Washignton Press, Seattle, London, x+365pp.

Kulkarni, A.R. & M.H. Desai (1972). Family Eriocaulaceae in Kolhapur and its Environs. *Journal of the Bombay Natural History Society* 69: 231–235.

Lad, R. & J. Samant (2009). Environmental and Social Impacts of Mining in the Western Ghats: A Case Study of Warna Basin http://cdn.livediverse.eu/wp-content/uploads/2009/10/Mining-Paper.pdf Downloaded on 27 September 2012.

Lekhak, M.M. & S.R. Yadav (2012). Herbaceous vegetation of threatened high altitude lateritic plateau ecosystems of Western Ghats, southwestern Maharashtra, India *Rheedea* 22(1): 39–61.

Mishra, D.K. & N.P. Singh (2001). *Endemic and threatened flowering plants of Maharashtra*. Botanical Survey of India, Calcutta, 414pp.

Molur, S., K.G. Smith, B.A. Daniel & W.R.T. Darwell (compilers) (2011). *The Status and Distribution of Freshwater Biodiversity in The Western Ghats, India.* Cambridge, U.K. and IUCN, Gland Switzerland and Zoo Outreach Organisation, Coimbatore, India.

Mota, J.F., A.J. Sola, M.L. Jimenez-Sanchez, F.J. Perez-Garcia & M.E. Merlo (2004). Gypsicolous flora, conservation and restoration of quarries in I southeast of the Iberian Peninsula. *Biodiversity and conservation* 13: 1797–1808.

Ojeda, F., T. Maranon & J. Arroyo (2000). Plant diversity patterns in the Aljibe Mountains (S. Spain): a comprehensive account. *Biodiversity and conservation* 9: 1323–1343.

Ollier, C.D. & H. Sheth (2008). The High Deccan duricrusts of India and their significance for the 'laterite' issue. *Journal of Earth System Science* 117(5): 537–551.

Pande, S., A. Padhye, P. Deshpande, A. Ponkshe, P. Pandit, A. Pawashe, S. Pednekar, R. Pandit & P. Deshpande (2013). Avian collision threat assessment at 'Bhambarwadi Wind Farm Plateau' in northern Western Ghats, India. *Journal of Threatened Taxa* 5(1): 3504–3515

Porembski, S. & G. Brown (1995). The vegetation of Inselbergs in the Comoe National Park (Ivory Coast). *Candollea* 50: 351–365.

Porembski, S. & A. Watve (2005). Remarks on the species composition of Ephemeral Flush Communities on paleotropical rock outcrops. *Phytocoenologia* 35(2–3): 389–401.

Porembski, S. & W. Barthlott (2000) (eds.). *Inselbergs - Biotic Diversity of Isolated Rock Outcrops in Tropical and Temperate Regions*. Ecological studies 146. Springer, Heidelberg, 524pp.

Porembski, S., E. Fischer & N. Biedinger (1997). Vegetation of inselbergs, quartzitic outcrops and ferricretes in Rwanda and eastern Zaire (Kivu). *Bulletin du Jardin Botanique National de Belgique - Bulletin van de Nationale Plantentuin van België* 66: 81–99.

Porembski, S., U. Becker & R. Seine (2000). Islands on islands: habitats on Inselbergs. *Ecological Studies* 146: 49–67. In: Porembski, S. & W. Barthlott (eds.). *Inselbergs - Biotic Diversity of Isolated Rock Outcrops in Tropical and Temperate Regions*. Ecological studies 146. Springer, Heidelberg, 524pp.

Porembski, S., W. Barthlott, S. Dörrstock & N. Biedinger (1994). Vegetation of rock outcrops in Guinea: granite inselbergs, sandstone table mountains, and ferricretes - remarks on species numbers and endemism. *Flora* 189: 315–326.

Prasad, V.P. & N.P. Singh (1999). Two new species of *Fimbristylis* (Cyperaceae) from Western Peninsular India. *Journal of the Bombay Natural History Society* 96(3): 454–458.

Richards, P.W. (1957). Ecological notes on the West African vegetation I. The plant communities of Indanre hills, Nigeria. *Journal of Ecology* 45: 563–577.

Seine, R., U. Becker, S. Porembski, G. Follmann & W. Barthlott (1998). Vegetation of inselbergs in Zimbabwe. *Edinborough Journal of Botany* 55: 267–293.

Sharma, B.D., S. Karthikeyan & N.P. Singh (1996). *Flora of Maharashtra State: Monocotyledones*. Flora of India Series 2. Botanical Survey of India, Calcutta, 794pp.

Shukla, P.K., G.K. Srivastava & S.K. Shukla (2002). The quillworts (*Isoetes*) of India: distribution, endemism and species radiation. *Biodiversity and conservation* 11: 959–973.

Singh, N.P., P. Lakshminarasimhan, S. Karthikeyan & P. V. Prasanna (2001). *Flora of Maharashtra State: Dicotyledones Volume. 2*. Flora of India Series 2. Botanical Survey of India, Calcutta, 1080pp.

Singh, N.P. & S. Karthikeyan (2000). *Flora of Maharashtra State: Dicotyledones 1.* Flora of India Series 2. Botanical Survey of India, Calcutta, 898pp.

Stevanović, V., K. Tan & G. Iatrou (2003). Distribution of the endemic Balkan flora on serpentine I. - obligate serpentine endemics. *Plant Systematics and Evolution* 242(1–4): 149–170.

Tetali, P., S. Tetali, B.G. Kulkarni, P.V. Prasanna, P. Lakshminarasimhan, M. Lale, M.S. Kumbhojkar, D.K. Kulkarni & A.P. Jagtap (2000). Endemic plants of India: A status report of Maharashtra State. Naoroji Godrej Centre for Plant Research, Shirwal, 87pp.

Thakur, S. & A. Watve (2004). Report of lesser kestrel (*Falco naumanni* Fleischer) flock near Thoseghar, Satara District Maharashtra. *Newsletter for Birdwatchers* 44(6): 60.

Verboom, W.H. & J.S. Pate (2001). Relationships between cluster root-bearing taxa and laterite across landscapes in southwest Western Australia: an approach using airborne radiometric and digital elevation models. *Plant and Soil* 00: 1–13.

Von Gaisberg, M. & C. Stierstorfer (2005). The significance of geological traits for the speciation of endemic angiosprms on El Hierro (Canary Islands). *Phytocoenologia* 35: 39–52.

Watve, A. (2003a). Vegetation on rock outcrops in northern Western Ghats and Konkan region, Maharasthra. *Geobios* 30: 41–46.

Watve, A. (2003b). Vegetation on Rock Outcrops in Northern Western Ghats and Konkan Region, Maharasthra, pp. 185–190. In: Janarthanam, M.K. & D. Narasimhan (eds.). *Plant Diversity, Human Welfare and Conservation*. Goa University, Goa, 380pp.

Watve, A. (2007). Report of the study Plant communities on rock outcrops in Northern Western Ghats. Report submitted to Department of Science and Technology. Agharkar Research Institute, Pune, 51pp.

Watve, A. (2008). Special habitats: rock outcrops in northern Western Ghats. Special Habitats and threatened plants of India, Wildlife and Protected Areas. *ENVIS* 11(1): 147–153.

Watve, A. (2010). Rocky Plateaus: Special focus on Northern Western Ghats and Konkan. Western Ghats Ecology Experts Panel (WGEEP). www.westernghatsindia.org/sites/default/files/Rocky%20Plateaus.pdf, Downloaded on 25 September 2012.

Watve, A. & S. Thakur (2006). Ecological studies of lateritic plateau habitats in Northern Western Ghats, pp. 22–28. In: Pandey H.N. & S.K. Barik (eds.) *Ecology, Diversity and Conservation of Plants and Ecosystems in India.* Regency Publications, New Delhi, xvi+436pp.

Widdowson, M. & K.G. Cox (1996). Uplift and erosional history of the deccan traps India: Evidence from laterites and drainage patterns of the Western Ghats and Konkan coast. *Earth and Planetary Science Letters* 137: 57–69.

Wiser, S.K. & P.S. White (1999). High elevation outcrops and barrens of the southern Appalachian mountains, pp. 119–132. In: Anderson, R.C., J. Fralish & J. Baskin (eds.). *Savannas, Barrens and Rock Outcrop Communities of North America.* Cambridge University press, USA, ix+470pp.

Yadav, S.R. & M.M. Sardesai (2002). *Flora of Kolhapur District.* Shivaji University, Kolhapur, 679pp.

Marathi Abstract: उत्तर सह्याद्री आणि कोकणातील खडकाळ पठारे ही खडकाळ अधिवासातील एक वैशिष्टयपूर्ण प्रकार आहेत. या पठारांचे वर्गिकरण, वितरण, पर्यावरण आणि माती बद्दलची माहिती ह्या लेखात दिलेली आहे. खडकाळ पठारांवरील सूक्ष्म अधिवासात वाढणाऱ्या खास प्रजातींचे गट आणि मानवी प्रभावामुळे त्यात होणारे बदल यांचे वर्णन केले आहे. काही प्रातिनिधीक जागांच्या पर्यावरणीय अभ्यासातून खूप प्रजाती संख्या आणि प्रजाती संपन्नता (H') दिसून आली. आत्तापर्यंतच्या माहितीचा आढावा घेतल्यावर असे दिसून येते कि येथे प्रदेशनिष्ठ वनस्पती आणि प्राण्यांची संख्या जास्त आहे आणि त्यापैकी अनेकांचा समावेष धोक्यात असलेल्या प्रजातींच्या यादीत केला गेलेला आहे. वनस्पती आणि प्राण्यांच्या जातीमध्ये मध्ये अनेकवेळा स्थानिक वैविध्य दिसते, त्यावरून अजूनही नवीन प्रजाती तयार होण्याची प्रक्रिया चालू असावी असा अंदाज येतो. संरक्षित वनप्रदेशामध्ये असलेली पठारे सोडून सर्व ठिकाणी मानवी हस्तक्षेपचे परिणाम दिसतात. खडकाळ पठारावरिल संपन्न जीविधेस कुठलेही खास कायदेशीर संरक्षण नाही. प्रस्तुत लेखात, पठारांवर पुढील काळात काय प्रकारच्या संशोधनाची गरज आहे हे सुचवले आहे. याखेरीज पठारांच्या पर्यावरणानुरूप व्यवस्थापन कसे असावे याबद्दलही सूचना केल्या आहेत.