

Geophytes of northern Western Ghats (Sahyadri Ranges) of India: a checklist

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Abstract: The geophytes in the northern Western Ghats are a significant component of the herbaceous flora, both in terms of abundance and diversity, and comprise approximately 10% of plant species. About 186 geophytic taxa were here recorded from northern Western Ghats of India during the present work. Of them, 62 geophytes are known only from northern Western Ghats. At least 22 plant families exhibit this life form. In the study region, geophytes have adapted to a monsoon seasonality. They sprout new foliage with the onset of monsoon rain in June and complete their life cycle in October when monsoon rains halt. Many of them produce flowers during the vegetative growing season but some charismatically flowers in summer season (April–May), often without leaves. A few taxa have abandoned their geophytic habit and grow in seasonal water bodies, and possess leaves without stomata and non-buoyant seeds.

Key words: geophytes, diversity, life-forms, endemism, Western Ghats

INTRODUCTION

Geophytes are plants with underground perennial organs (bulbs, corms, tubers or rhizomes) which enable them to survive over unfavorable seasons (Raunkiaer 1934). Although some geophyte species are evergreen, many have adapted to periods of environmental stress such as summer drought or winter cold by dying back to these underground storage organs (Dafni *et al.* 1981). They then sprout new foliage in the next favorable season. Inflorescences may be produced before, during or at end of the vegetative growing season; a phenology which is constant for most species. Biogeographically, geophytes are widespread around the world in many habitats, but they are most diverse and abundant in the five Mediterranean-climate ecosystems (Doutt 1994; Rundel 1996). The Cape Mediterranean zone of South Africa is generally the most speciose with geophytes comprising up to 40% of some regional floras (Goldblatt 1978; Snijman and Perry 1987).

The remarkable diversity of geophytes in the northern Western Ghats can be seen clearly in the herbaceous flora of lateritic plateaus where geophytes comprise up to 35% of the flora (Lekhak and Yadav 2012). Regional floristic studies have

also reported the occurrence of a high number of geophytes in the northern Western Ghats (Cooke 1901–1908; Santapau 1953; Almeida 1990; Lakshminarasimhan and Sharma 1991; Deshpande *et al.* 1995; Lakshminarasimhan 1996; Pradhan and Singh 1999; Singh *et al.* 2000; 2001; Yadav and Sardesai 2002). It is not only the diversity of geophytes in the northern Western Ghats that is remarkable, but also the diversity of growth-forms. In addition to the typical monocot geophytes with rosettes of basal leaves these geophytes exhibit various growth-forms, such as prostrate leaf geophytes (1 or 2 leaves oriented 180° from each other), single leaf herbs, small cormatous herbs with grass-like leaves, and tuberous herbaceous climbers. Each of these growth-forms has a functional significance.

During the last few decades, many habitats have been affected by mining, windmills, widening of roads, construction of townships and industries in the northern Western Ghats (Watve 2013). Tourism has been growing in some of the scenic areas putting pressure on fragile habitats in the study region. The management of these pressures is often misguided due to poor understanding of the different life forms. In light of this, the present study was carried out to document the diversity of geophytes and to provide a threat assessment of the rare, endangered and endemic geophytic taxa of the northern Western Ghats. The baseline data generated in this study will greatly help in conservation of threatened geophytic taxa.

MATERIALS AND METHODS

Study site

The Western Ghats of India is a well-known global hotspot recognized for exceptional biotic diversity and endemism (Padhey and Ghate 2002; Gunawardene *et al.* 2007; Daniel and Vencatesan 2008), accompanied by an alarming level of habitat loss (Davidar *et al.* 2007; Panigrahy *et al.* 2010). Due to its exceptional biota, the Western Ghats has been recognized by UNESCO as a World Heritage Site (United Nations Educational, Scientific and Cultural Organization 2012). The northern half of the Western Ghats of India is locally known as Sahyadri Mountain. It is a chain of flat top mountains of about 750 km in length running parallel to West Coast of the Peninsular India from the river Tapi, South Gujarat (21°03'59.62" N, 073°39'08.44" E) to Goa (14°56'14.95" N, 074°06'49.18" E). The

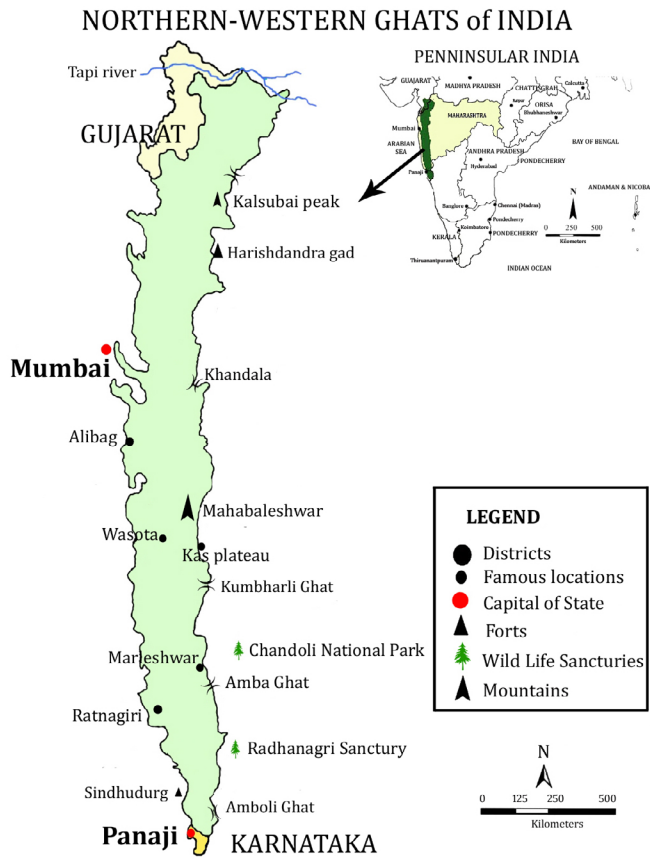


Figure 1. Map of northern Western Ghats (Sahyadri ranges) of India, including collection localities (see text).

biogeographical province of Sahyadri Mountain covers about 6,500 km² of mountainous terrain. It straddles the states of South Gujarat, Maharashtra and Goa (Figure 1). The climate is characterized by monsoon rain and can be divided into three seasons, a rainy season (June–October), a winter season (November–February) and a summer season (March–May). Thus, the monsoon season (rainy season) is followed by a considerable stretch of dry period between November and May. During the monsoon, the study region receives high rainfall (600–700 cm) that results in a relative humidity of up to 94%. Nevertheless, it is just 14% during hot and dry summer on open rocky plateaus and exposed hill slopes, when temperature reach up to 42°C in summer.

Data collection

Field visits undertaken to various localities of the northern Western Ghats of India, which included Ambolighat, Ambaghat, Chandoli National Park, Harishchandra, Kalsubai Hills, Kas Plateau, Mahabaleshwar, Marleshwar, Radhanagri Wildlife Sanctuary and Wasotafort (Figure 1). During field visits, information on habitat, distribution, endemism, growth form, vegetative growing season and period of flowering and fruiting was gathered. Collected plant species were identified by consulting relevant literature and regional floras (Cooke 1901–1908; Santapau 1953; Almeida 1990; Lakshminarasimhan and Sharma 1991; Lakshminarasimhan 1996; Pradhan and Singh 1999; Singh *et al.* 2000; 2001; Yadav and Sardesai 2002). The identity of the geophytic species was

confirmed at Botanical Survey of India, Pune (BSI) and Blatter Herbarium, Mumbai (BLAT). Author citation and binomial of collected species verified with international Plant name Index (IPNI). Raunkiaer’s system of classification (1934) was used for life form categorization. The IUCN Red List Categories and Criteria version 3.1 (IUCN 2001) was used for assessment of the present status of the geophyte taxa. In the present paper, the families are arranged according to APG III (2009). Important plant species are featured in the Figures 2–9.

RESULTS

The geophytes exhibit remarkable species diversity and comprise approximately 10% plant species of the total flora of northern Western Ghats of India. During the present work, 186 geophyte taxa belong to the 22 different plant families were recorded from northern Western Ghats of India of which 101 are endemic. *Habenaria* Willd. was found to be the best represented genus with 26 species, followed by *Ceropegia* L. with 23 taxa. Among the 186 geophyte taxa in the region, 127 are tuberous, 33 bulbous, 19 rhizomatous and 7 are cormatous. The critical field survey has shown that 21 taxa fall into Critically Endangered category of IUCN, 14 into Endangered, 10 into Vulnerable, 14 into Near Threatened, 30 into Least Concern, and 10 into Data Deficient and 87 into Not Evaluated.

DISCUSSION

The present study is an outcome of intensive and extensive field collections and herbarium studies carried between the years 2008–2012. During the present work, 186 geophyte taxa have recorded from northern Western Ghats of India (Table 1). They are belonging to the 22 families. *Habenaria* Willd. was found to be the largest genus with 26 geophyte taxa in the study region, followed by *Ceropegia* L. with 23 taxa. Among the 186 geophyte taxa in the region, 127 are tuberous, 33 bulbous, 19 rhizomatous and 7 cormatous. About 62 taxa are restricted to the northern Western Ghats (Ahmedullah and Nayar 1986; Nayar and 1996; Mishra and Singh 2001; Gaikwad and Yadav 2004; Gaikwad *et al.* 2014a). The genus *Ceropegia* shows the highest incidence of endemism with 20 endemic taxa (85.95%), followed by genus *Habenaria* with 14 (53.84%) endemic taxa. Most of the endemic taxa are restricted to small biogeographical areas and are rare in occurrence. Their populations have been declining rapidly due to habitat modification and anthropogenic pressures.

Apart from species richness, geophytes exhibit several interesting growth forms in the study region (Table 1). Each of these growth forms has functional significance. In case of prostrate leaf geophytes, flat leaves reduce the rate of water loss around the roots. Lovegrove (1993) has stated that prostrate leaves act as water-trapping umbrellas, reducing the rate of water loss, and creating favorable microclimates for growth. According to Karen *et al.* (1999), prostrate leaves create a CO₂ enriched environment below. A moist environment under leaves could encourage activity of microorganism, which in turn produce CO₂. A CO₂ enriched environment might increase photosynthetic CO₂ uptake. Geophytes possess grass like leaves that provide camouflage amongst grasses, and are therefore more difficult for herbivores to recognize; thus protecting plants against herbivory.

In the northern Western Ghats, the annual life cycle of

geophytes involves flowering in the monsoon season, from June to October. They produce seeds rapidly and aerial parts die back to underground perennial organs so that the plants remain dormant in long dry season. New leaves are usually produced in response to the monsoon rain in the month of June, and vegetative growth continued until October. Inflorescences are usually produced during or to the end of the vegetative growing season. However, several genera, mostly among monocotyledons (e.g., *Amorphophallus*, *Chlorophytum*, *Crinum*, *Curcuma* and *Drimia*) and a few of dicotyledonous (e.g., *Brachystelma* and *Euphorbia*) have changed this pattern of flowering. They flower in the summer (April–May), often without leaves. The monsoon flowering species are generally synanthous, i.e., with flowers and leaves developing simultaneously, whereas the summer flowering ones are often hysteranthous, i.e., with flowers and leaves developing in different seasons. Beside the above-mentioned two patterns of flowering, some geophytes like *Euphorbia fusiformis*, *E. fusiformis* var. *khandalensis*, *Habenaria viridiflora*, *Zeuxine gracilis* and *Z. longilabris* flower in the winter season (Soumen 2010; Binojkumar and Balakrishnan 2010). In fact, a flowering period is constant for most of the geophytes species.

Two types of seeds are observed in geophytes—one with a hard seed coat that makes the seeds highly buoyant, and the other is chlorophyllous, which is probably lacking a cork layer, as seeds are non-buoyant. The first seed type is recorded in the genera *Chlorophytum*, *Dipcadi*, *Drimia*, *Iphigenia* and *Pancratium*, while the second type is known for *Aponogon bruggenii*, *A. satarensis*, *Crinum solapurense* and *Crinum viviparum* var. *viviparum* (Koshimizu 1930; Hannibal 1966; Manasse 1990; Yadav and Gaikwad 2003; Bjora et al. 2006; Gaikwad et al. 2014b). In fact, the latter species have adapted to an aquatic habitat.

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Table 1. List of geophytes of the northern Western Ghats of India. Abbreviations: **endemism & IUCN categories:** CR= Critically Endangered, EN= Endangered, VU= Vulnerable, NT= Near Threatened, LC= Least Concern, NE= Not Evaluated, DD= Data Deficient and E= Endemic; **habit/growth form:** BLG= Bulbous lilioid geophytes, FDG= fleshy delicate geophytes, PLG= prostrate leaves geophytes, RG=rhizomatous geophytes, RLG= radial/rosette leaves geophytes, CSG= cormatous small geophytes, SLG= single leaf geophytes, SAQG= seasonal aquatic geophytes and TG= tuberous geophytes. Asterisk (*) indicates plants are restricted to the northern Western Ghats.

Taxa	Habitat	Habit / Growth form	Phenology of flowering	Endemism & IUCN categories	Field No.
Araceae					
<i>Amorphophallus bulbifer</i> (Roxb.) Blume	Forest borders	SLG	Apr.–May	NE	SUK-SPG 1113
<i>Amorphophallus commutatus</i> (Scott.) Engl.	Forest borders	SLG	Apr.–Sept.	E, LC	SUK-SPG 1125
* <i>Amorphophallus konkanensis</i> Hett, Yadav & Patil	Open ground and slopes at 100 m alt.	SLG	Apr.–June	E, NT	SUK-SPG 1328
<i>Amorphophallus paeoniifolius</i> (Dennst.) Nicols.	Forest borders	SLG	June–Sept.	NE	SUK-SPG 1386
<i>Ariopsis peltata</i> Nimmo	Crevice of wet hanging rocks	SLG	June–Aug.	NE	SUK-SPG 1458
* <i>Arisaema caudatum</i> Engl.	Forest margins at 1,000–1,200 m alt.	SLG	June–Sept.	E, EN	SUK-SPG 1527
<i>Arisaema leshenaultii</i> Blume	Forest margins at 1,000–1,200 m alt.	SLG	June–Nov.	E, NT	SUK-SPG 1469
* <i>Arisaema murrayi</i> (Grah.) Hook.	Crevice of rocks on lateritic plateaus at 1,000–1,200 m alt.	SLG	June–Oct.	E, VU	SUK-SPG 1549
* <i>Arisaema sahyadricum</i> Yadav, Patil & Bachulkar var. <i>sahyadricum</i>	Around bushes at 800–1,200 m alt.	SLG	June–July	E, EN	SUK-SPG 1389
* <i>Arisaema sahyadricum</i> Yadav, Patil & Bachulkar var. <i>ghaticum</i> Sardesai, Gaikwad & Yadav	Around bushes at 800–1,200 m alt.	SLG	May–July	E, EN	SUK-SPG 1716
* <i>Arisaema sivasanii</i> Yadav, Patil & Janarthanam	Forest borders at 1,000–1,200 m alt.	SLG	June–Sept.	E, EN	SUK-SPG 1599
<i>Arisaema tortuosum</i> Scott. var. <i>neglectum</i> (Scott.) Fiscg.	Forest borders at 1,000–1,200 m alt.	SLG	July–Sept.	NT	SUK-SPG 1614
<i>Remusatia vivipara</i> (Roxb.) Scott. & Endl.	Tree trunks or crevice of wet rocks	SLG	Apr.–Sept.	NE	SUK-SPG 1348
<i>Sauromatum venosum</i> (Ait.) Scott.	Hill tops and slopes	SLG	Mar.–May	NE	SUK-SPG 1916
* <i>Theriophonum dalzellii</i> Scott	Lateritic plateaus in the Konkan region	SLG	Aug.–Oct.	E, LC	SUK-SPG 1781
<i>Typhonium bulbiferum</i> Dalz.	Around small bushes	SLG	June–July	E, LC	SUK-SPG 1650

Continued

Table 1. Continued.

Taxa	Habitat	Habit / Growth form	Phenology of flowering	Endemism & IUCN categories	Field No.
<i>Typhonium flagelliformae</i> (Roxb.) ex Lodd.) Rumph	Around small bushes	SLG	June--Sept.	E, NE	SUK-SPG 1110
<i>Typhonium roxburghii</i> Scott.	Lateritic plateaus 100–200 m alt.	SLG	June–July	LC	SUK-SPG 1755
<i>Typhonium trilobatum</i> (L.) Scott.	Shady moist places in moist deciduous forests	SLG	June–Aug.	E, EN	SUK-SPG 1499
Aponogetonaceae					
* <i>Aponogeton bruggenii</i> Yadav & Govekar	Paddy fields at 100 m alt.	SAQG	Aug.–Sept.	E, CR	SUK-SPG 2021
* <i>Aponogeton satarensis</i> Raghavan, Kulkarni & Yadav	Temporary ponds/puddles on lateritic plateaus at 1,000 m alt.	SAQG	May–Sept.	E, CR	SUK-SPG 1366
Taccaceae					
<i>Tacca leontopetaloides</i> (L.) O. Ktze.	Forest margins	SLG	July–Oct.	NE	SUK-SPG 2495
Colchicaceae					
* <i>Campyrorhiza indica</i> Yadav, Singh & Matthew	Lateritic plateaus at 100 m alt.	CSG	June–July	E, CR	SUK-SPG 2411
<i>Gloriosa superba</i> L.	Open forests	TG	July–Nov.	NE	SUK-SPG 1894
<i>Iphigenia indica</i> (L.) A. Gray	Grassy hill slopes	CSG	June–Sept.	NE	SUK-SPG 2121
<i>Iphigenia magnifica</i> Ansari & Rolla	Grassy hill slopes	CSG	Sept.–Dec.	E, VU	SUK-SPG 2379
<i>Iphigenia pallida</i> Baker	Grassy hill slopes	CSG	July–Sept.	E, LC	SUK-SPG 1471
* <i>Iphigenia stellata</i> Blatt.	Grassy hill slopes at 800–1,200 m alt.	CSG	June–Sept.	E, VU	SUK-SPG 1977
Amaryllidaceae					
<i>Crinum asiaticum</i> L. var. <i>asiaticum</i>	Cultivated or sometimes naturalized	BLG	July–Sept.	NE	SUK-SPG 2099
* <i>Crinum brachynema</i> Herb.	Open hill slopes at 1,200 m alt.	BLG	Apr.–May	E, CR	SUK-SPG 2567
* <i>Crinum eleonare</i> Blatt. & McCann. var. <i>elenoare</i>	Open hill slopes at 1,200 m alt.	BLG	Apr.–May	E, DD	SUK-SPG 1380
* <i>Crinum eleonare</i> Blatt. & McCann. var. <i>purpurea</i> Blatt. & McCann.	Open hill slopes at 1,200 m alt.	BLG	Apr.–May	E, DD	SUK-SPG 1693
<i>Crinum latifolium</i> L.	Cultivated/escaped	BLG	May–Sept.	NE	SUK-SPG 2266
<i>Crinum lorifolium</i> Roxb. ex Ker.-Gawl.	Gravelly ground in open forests	BLG	Oct.–Dec.	NE	SUK-SPG 1957
<i>Crinum viviparum</i> (Lam.) Ansari & Nair	Wet margins of temporary streams	SAQG	June–Oct.	NE	SUK-SPG 1330
* <i>Crinum woodrowii</i> Baker	Open hill slopes at 1,200 m alt.	BLG	May–June	E, CR	SUK-SPG 1418
<i>Pancratium biflorum</i> Roxb.	Open ground/hill slopes	BLG	June–Sept.	NE	SUK-SPG 2625
<i>Pancratium donaldii</i> Blatt.	Open ground/hill slopes	BLG	June–Sept.	NE	SUK-SPG 1520
<i>Pancratium longiflorum</i> Roxb.	Gravelly hill slopes	BLG	June–Sept.	NE	SUK-SPG 2553
<i>Pancratium parvum</i> Dalz.	Gravelly hill slopes	BLG	June–Aug.	E, LC	SUK-SPG 2147
* <i>Pancratium sanctae-mariae</i> Blatt. & Hallb.	Gravelly hill slopes	BLG	May–June	E, DD	SUK-SPG 1298
<i>Pancratium triflorum</i> Roxb.	Gravelly hill slopes	BLG	Apr.–May	NE	SUK-SPG 1390
Asparagaceae					
* <i>Dipcadi concanense</i> (Dalz.) Baker	Open ground in Konkan region	BLG	Aug.–Sept.	E, EN	SUK-SPG 2666
* <i>Dipcadi maharashtrense</i> Deb & Dasg.	Open ground	BLG	Aug.–Sept.	E, CR	SUK-SPG 1379
* <i>Dipcadi minor</i> Hook. f.	Open ground	BLG	June–Aug.	E, DD	SUK-SPG 1212
<i>Dipcadi montanum</i> (Dalz.) Baker	Open ground	BLG	June–Aug.	NE	SUK-SPG 1784
* <i>Dipcadi saxorum</i> Blatt.	Hill slopes at 800–1,000 m alt.	BLG	June–Nov.	E, VU	SUK-SPG 2785
<i>Dipcadi ursulae</i> Blatt.	Wet hill slopes	BLG	July–Aug.	E, LC	SUK-SPG 2830
<i>Drimia congesta</i> Bullock	Open gravelly ground	BLG	Apr.–May	NE	SUK-SPG 1438
<i>Drimia indica</i> (Roxb.) Jessop	Open gravelly ground	BLG	Feb.–May	NE	SUK-SPG 1767
<i>Drimia polyantha</i> (Blatt. & Mc C.) Stearn	Open waste land	BLG	Mar.–July	NE	SUK-SPG 2354
* <i>Drimia polyphylla</i> (Hook. f.) Ansari & S. Raghav.	Open ground	BLG	Aug.–Sept.	E, DD	SUK-SPG 1819
* <i>Drimia razii</i> Ansari	Exposed rocky hill slopes	BLG	Mar.–Apr.	E, CR	SUK-SPG 2157
<i>Scilla hyacinthiana</i> (Roth) Mc Bride	Open gravelly ground/hill slopes	BLG	June–Sept.	E, LC	SUK-SPG 989
* <i>Scilla viridis</i> Blatt. & Hallb.	Open ground	BLG	Jan.–Mar.	E, DD	SUK-SPG 1660
Anthericaceae					
<i>Chlorophytum bharuchae</i> Ansari, Raghavan & Hemadri	Gravelly hill slopes	RLG	May–Aug.	E, NT	SUK-SPG 897
<i>Chlorophytum borivillianum</i> Sant. & Fernan.	Lateritic plateaus at 200 m alt. in the Konkan region	RLG	July–Aug.	E, CR in wild	SUK-SPG 1986
<i>Chlorophytum breviscapum</i> Dalz.	Gravelly hill slopes	RLG	Aug.–Nov.	E, LC	SUK-SPG 1873
* <i>Chlorophytum glaucoides</i> Blatt.	Gravelly hill slopes	RLG	Sept.–Oct.	E, LC	SUK-SPG 2714
<i>Chlorophytum glaucum</i> Dalz.	Gravelly hill slopes	RLG	July–Sept.	E, LC	SUK-SPG 2856
* <i>Chlorophytum gothanense</i> Malure & Yadav	Lateritic plateaus at 1200 m alt.	RLG	July–Sept.	E, EN	SUK-SPG 1948
* <i>Chlorophytum kolphapurensis</i> Sardesai, Gaikwad & Yadav	Open gravelly slopes	RLG	June–Sept.	E, CR	SUK-SPG 1153
<i>Chlorophytum laxum</i> R. Br.	Open gravelly ground	RLG	July–Sept.	NE	SUK-SPG 1577
<i>Chlorophytum nimmonii</i> (Grah.) Dalz.	Exposed hill slopes	RLG	July–Oct.	NE	SUK-SPG 2333
<i>Chlorophytum tuberosum</i> (Roxb.) Baker	Open gravelly ground	RLG	June–Sept.	NE	SUK-SPG 2166

Continued

Table 1. Continued.

Taxa	Habitat	Habit / Growth form	Phenology of flowering	Endemism & IUCN categories	Field No.
Hypoxidaceae					
<i>Curculigo orchiooides</i> Gaertn.	Gravelly hill slopes/tree shades in deciduous forests	RLG	June–Oct.	NE	SUK-SPG 998
<i>Hypoxis aurea</i> Lour.	Gravelly hill slopes	RLG	May–Nov.	NE	SUK-SPG 1314
Orchidaceae					
<i>Eulophia epidendrea</i> (Retz.) Fischer	Open ground/hill slopes	RLG	Nov.–Mar.	NE	SUK-SPG 888
<i>Eulophia graminea</i> Lindl.	Open ground/hill slopes	RLG	July–Sept.	NE	SUK-SPG 995
<i>Eulophia herbacea</i> Lindl.	Hill slopes	RLG	July–Sept.	E, NT	SUK-SPG 1793
<i>Eulophia ochreatea</i> Lindl.	Hill slopes in loose soil	RLG	July–Sept.	E, NT	SUK-SPG 1122
<i>Eulophia nuda</i> Lindl.	Open ground/hill slopes/bunds of fields	RLG	June–Sept.	NE	SUK-SPG 1777
<i>Eulophia ramentacea</i> Lindl. ex Wight	Among grasses on bank of lakes	RLG	Dec.–Mar.	E, NT	SUK-SPG 2150
<i>Geodorum densiflorum</i> (Lam.) Schltr.	Loose black and sandy soil in shady places	RLG	June–Dec.	NE	SUK-SPG 950
* <i>Habenaria caranjensis</i> Dalz.	Sea coast	RLG	Aug.–Sept.	E, DD	SUK-SPG 810
<i>Habenaria commelinifolia</i> (Roxb.) Wall. ex Lindl.	Slopes in deciduous forests	RLG	Aug.–Sept.	NE	SUK-SPG 2990
<i>Habenaria crassifolia</i> A. Rich.	Amidst in grasses at 1,000 m alt.	PLG	Aug.–Sept.	E, NE	SUK-SPG 2784
<i>Habenaria crinifera</i> Lindl.	Wet rocks/tree trunks	RLG	Aug.–Sept.	NE	SUK-SPG 1518
<i>Habenaria digitata</i> Lindl.	Amidst in grasses on slopes	RLG	July–Dec.	NE	SUK-SPG 2149
<i>Habenaria diphylla</i> (Nimmo) Dalz.	Amidst in grasses on slopes	PLG	July–Oct.	NE	SUK-SPG 1376
<i>Habenaria foliosa</i> A. Rich. var. <i>foliosa</i>	Undergrowth in <i>Carvia callosa</i> at 900 m alt	RLG	July–Sept.	E, EN	SUK-SPG 2829
<i>Habenaria foliosa</i> A. Rich. var. <i>foetida</i> (Blatt et. McCann) Bennet	Humus rich soil as undergrowth	RLG	Aug.–Dec.	NE	SUK-SPG 1528
<i>Habenaria foliosa</i> A. Rich. var. <i>gibsonii</i> (Hook. f.) Bennet	on steep slopes in loose soil as undergrowth in <i>Carvia callosa</i>	RLG	Aug.–Dec.	NE	SUK-SPG 1734
<i>Habenaria furcifera</i> Lindl.	Amidst in grasses on slopes	RLG	Aug.–Nov.	NE	SUK-SPG 1358
<i>Habenaria grandifloriformis</i> Blatt. & McCann.	Amidst in grasses in open ground	PLG	June–July.	E, LC	SUK-SPG 1763
<i>Habenaria heyneana</i> Lindl.	Amidst in grasses on slopes	RLG	Aug.–Nov.	E, LC	SUK-SPG 2967
<i>Habenaria hollandiana</i> Sant.	Amidst in grasses on slopes	RLG	Nov.–Dec.	E, LC	SUK-SPG 957
<i>Habenaria longicorniculata</i> Grah.	Open ground in grasses	RLG	July–Oct.	E, NE	SUK-SPG 1980
<i>Habenaria marginata</i> Colebr. var. <i>marginata</i>	Muddy places around bushes	RLG	July–Nov.	NE	SUK-SPG 2000
<i>Habenaria marginata</i> Colebr. var. <i>flavescens</i>	Wet grassland	RLG	Aug.–Dec.	NE	SUK-SPG 1617
<i>Habenaria multicauadata</i> Sedgew.	In moist shady places in evergreen forests	RLG	Aug.–Sept.	E, EN	SUK-SPG 1973
<i>Habenaria ovalifolia</i> Wight.	Amidst in grasses in open ground	RLG	Aug.–Nov.	E, LC	SUK-SPG 1867
* <i>Habenaria panchganiensis</i> Sant. & Kapadia	Lateritic plateaus at 1,000–1,200 m alt.	RLG	June–July	E, EN	SUK-SPG 1476
<i>Habenaria perrottetiana</i> A. Rich	Amidst in grasses at 1,000 m alt.	RLG	Aug.–Dec.	E, NE	SUK-SPG 1637
<i>Habenaria plantaginea</i> Lindl.	On slopes near bushes	RLG	Sept.–Oct.	NE	SUK-SPG 1919
<i>Habenaria rariflora</i> A. Rich.	On steep slopes in loose soil/wet hanging rocks	RLG	July–Nov.	E, NE	SUK-SPG 2087
<i>Habenaria roxburghii</i> Nicols.	Around bushes and rock crevices	PLG	July–Oct.	E, NT	SUK-SPG 2456
<i>Habenaria stenopetala</i> Lindl.	Amidst in grasses on open ground	RLG	Oct.–Dec.	NE	SUK-SPG 1542
* <i>Habenaria suvaeolens</i> Dalz.	Tree associated area	RLG	Aug.–Sept.	E, DD	SUK-SPG 1969
<i>Habenaria viridiflora</i> (Rottl. ex Sw.) R. Br. ex Spreng.	Amidst in grasses on open ground	RLG	Dec.–Jan.	NE	SUK-SPG 1159
<i>Liparis nervosa</i> (T.Gunb.) Lindl.	Near bushes at 800 m alt.	RLG	Aug.–Sept.	NE	SUK-SPG 1746
<i>Liparis rheedei</i> Lindl.	Open ground	RLG	Aug.–Sept.	NE	SUK-SPG 2350
<i>Nervilia aragoana</i> Gaud.	Near bushes as undergrowth	SLG	July–Sept.	NE	SUK-SPG 2557
<i>Nervilia discolor</i> (Bl.) Schult.	Near bushes as undergrowth	SLG	July–Sept.	NE	SUK-SPG 1028
<i>Nervilia infundibulifolia</i> Blatt. & Mc C.	Near bushes as undergrowth	SLG	July–June	NE	SUK-SPG 2299
<i>Nervilia plicata</i> (Andr.) Schltr.	Near bushes as undergrowth	SLG	July–Aug.	NE	SUK-SPG 1094
<i>Nervilia prainiana</i> (King. & Pantl.) Seid.	Near bushes as undergrowth	SLG	Aug.–Sept.	NE	SUK-SPG 1357
<i>Pecteilis gigantea</i> (J.E. Smith) Rafin.	Open places in deciduous forests	RLG	Aug.–Sept.	NE	SUK-SPG 1008
<i>Peristylus densus</i> (Lindl.) Sant. & Kapadia	Open ground	RLG	Aug.–Oct.	NE	SUK-SPG 1074
<i>Peristylus aristatus</i> Lindl.	Shady places at 900–1,000 m alt.	RLG	Aug.–Sept.	NE	SUK-SPG 967
<i>Peristylus densus</i> (Lindl.) Sant. & Kapadia	Amidst in grasses at 1,000–1,200 m alt.	RLG	Aug.–Sept.	NE	SUK-SPG 1691
<i>Peristylus gardneri</i> (Hook. f.) Kranzl.	Forest margins	RLG	Aug.–Sept.	NE	SUK-SPG 1857
<i>Peristylus lawii</i> Wight.	Amidst in grasses on slopes	RLG	July–Sept.	NE	SUK-SPG 1516
<i>Peristylus plantagineus</i> Lindl.	Shady places at 900 m alt.	RLG	July–Dec.	NE	SUK-SPG 2684

Continued

Table 1. Continued.

Taxa	Habitat	Habit / Growth form	Phenology of flowering	Endemism & IUCN categories	Field No.
<i>Peristylus richardianus</i> Wight	Denuded places	RLG	July–Sept	E, CR	SUK-SPG 2876
<i>Peristylus stocksii</i> (Hook. f.) Kranzl.	Open ground	RLG	July–Oct.	NE	SUK-SPG 2999
<i>Zeuxine gracillis</i> (Breda) Blume	Deep shady places in forest areas	CSG	Feb.–Apr.	NE	SUK-SPG 2552
<i>Zeuxine longilabris</i> (Lindl.) Trim.	Deep shady places in forest areas	CSG	Feb.–Mar.	NE	SUK-SPG 1550
Commelinaceae					
<i>Cyanotis tuberosa</i> (Roxb.) J.A. & J.H. CSGult.	Gravelly ground	TG	Aug.–Oct.	NE	SUK-SPG 1960
<i>Cyanotis concanensis</i> Hassk.	Gravelly ground	TG	Aug.–Nov.	E, LC	SUK-SPG 1727
Eriocaulaceae					
* <i>Eriocaulon tuberiferum</i> Kulkarni & Desai	Seasonal ponds on rocky plateaus at 1,000 m alt.	TG	July–Sept.	E, LC	SUK-SPG 2910
Costaceae					
<i>Costus speciosus</i> (Koen. ex Retz.) Smith	Bunds of fields/roadside at 800–1,200 m alt.	RG	Aug.–Feb.	NT	SUK-SPG 2846
Zingiberaceae					
<i>Amomum pterocarpum</i> Thw.	Stream beds in semi-evergreen forests	RG	Aug.–Feb.	NE	SUK-SPG 999
<i>Curcuma amada</i> Roxb.	Open ground/hill slopes	RG	June–Sept.	NE	SUK-SPG 1669
<i>Curcuma angustifolia</i> Roxb.	Open ground/hill slopes	RG	July–Sept.	NE	SUK-SPG 1470
<i>Curcuma aromatica</i> Salisb.	Open ground	RG	May–July	NT	SUK-SPG 2476
<i>Curcuma decipines</i> Dalz.	Exposed areas/hill slopes	RG	June–Aug.	NT	SUK-SPG 1924
* <i>Curcuma inodora</i> Blatt.	Barren plateaus/grasslands at 1,000 m alt.	RG	June–Sept.	E, LC	SUK-SPG 1880
<i>Curcuma neilgherrensis</i> Wight	Exposed areas/hill slopes at 1,000 m alt.	RG	May–June	E, LC	SUK-SPG 1010
<i>Curcuma pseudomontana</i> Grah.	Crevice of rocks on lateritic plateaus	RG	July–Sept.	E, NE	SUK-SPG 1019
* <i>Curcuma purpurea</i> Blatt.	Crevice of rocks on lateritic plateaus at 800–1,200 m alt.	RG	June–July	E, DD	SUK-SPG 1788
* <i>Hitchenia caulina</i> (Grah.) Baker	Crevice of lateritic plateaus at 800–1,200 m alt.	RG	July–Oct.	E, LC	SUK-SPG 1979
<i>Globba martina</i> L.	Under shade in forest area	RG	July–Sept.	NE	SUK-SPG 2953
<i>Kaempferia scaposa</i> (Nimmo) BenTG.	Open ground	RG	July–Nov.	NT	SUK-SPG 1711
<i>Zingiber cernuum</i> Dalz.	Shady places along forest margins	RG	July–Dec.	E, LC	SUK-SPG 1047
* <i>Zingiber neesanum</i> (Grah.) Ramam.	Shady places along forest margins	RG	July–Sept.	E, LC	SUK-SPG 1306
<i>Zingiber montanum</i> (Konig) Link ex Dietr.	Shady places along forest margins	RG	July–Sept.	NE	SUK-SPG 1609
<i>Zingiber purpureum</i> Rosc.	Shady places along forest margins	RG	July Sept.	NE	SUK-SPG 1054
<i>Zingiber zerumbet</i> (L.) Rosc. ex J.E. Sm.	Shady places along streams & forest margins	RG	July–Sept.	NE	SUK-SPG 1901
Euphorbiaceae					
* <i>Euphorbia fusiformis</i> Buch.–Ham. ex D. Don	Soil deposition on lateritic plateaus at 1,000 m alt.	RLG	Feb.–Mar.	E, LC	SUK-SPG 2913
* <i>Euphorbia fusiformis</i> Buch.–Ham. ex D. Don var. <i>khandalensis</i> (Blatt. & Hallb.) Binojk. & Balakr.	Soil deposition on lateritic plateaus at 1,000 m alt.	RLG	Jan.– Mar.	E, NE	SUK-SPG 1001
Fabaceae					
<i>Flemingia nilgherrensis</i> (Baker) Wight ex Cooke	Crevice of rocks on lateritic plateaus at 1,000–1,200 m alt.	TG	Sept.–Oct.	E, LC	SUK-SPG 1333
* <i>Flemingia rollae</i> (Billore & Hemadri) Kumar	Crevice of rocks on lateritic plateaus at 1,200 m alt.	TG	Sept.–Oct.	E, EN	SUK-SPG 1694
<i>Flemingia tuberosa</i> Dalz.	Crevice of rocks on lateritic plateaus at 100–200 m alt.	TG	Aug.–Oct.	NT	SUK-SPG 1339
Begoniaceae					
<i>Begonia crenata</i> Dryand.	Crevice of wet rocks at 800–1,200 m alt.	TG	July–Sept.	E, LC	SUK-SPG 1,000
* <i>Begonia concanensis</i> DC.	Crevice of wet rocks at 1,000–1,200 m alt.	TG	Aug.–Oct.	E, VU	SUK-SPG
<i>Begonia intrigrifolia</i> Dalz.	Crevice of wet rocks at 1,000 m alt.	TG	Aug.–Sept.	NT	SUK-SPG 997
* <i>Begonia phrixophylla</i> Blatt. & McCann.	Crevice of wet rocks 1200 m alt.	TG	July–Aug.	E, DD	SUK-SPG 1544
<i>Begonia trichocarpa</i> Dalz.	Crevice of wet rocks at 1,000 m alt.	TG	Aug.–Dec.	NE	SUK-SPG 1837
Cucurbitaceae					
<i>Bryonia cretica</i> subsp. <i>dioica</i> (Jacq.) Tutin	Loose soil on slopes at 1,000 m alt.	TG	Aug.–Oct.	NE	SUK-SPG 1006

Continued

Table 1. Continued.

Taxa	Habitat	Habit / Growth form	Phenology of flowering	Endemism & IUCN categories	Field No.
<i>Kedrostis foetidissima</i> (Jacq.) Cogn.	In bushes on slopes	TG	Aug–Oct.	NE	SUK-SPG 1987
<i>Momordica balsamina</i> L.	Open forests areas up to 1,200 m alt.	TG	Aug–Oct.	NE	SUK-SPG 1690
<i>Momordica dioica</i> Roxb. ex Willd.	Open forests areas up to 1,200 m alt.	TG	Aug–Oct.	NE	SUK-SPG 1463
Balsaminaceae					
<i>Impatiens acaulis</i> Arn.	Crevice of wet hanging rocks/ tree trunks	TG	July–Sept.	NE	SUK-SPG 1776
Asclepiadaceae					
<i>Brachystelma edulis</i> Coll.	Gravelly slopes at 700 m alt.	TDEG	May–June	NE	SUK-SPG 1866
* <i>Brachystelma malwanense</i> Yadav & Singh	In crevices of rocks on lateritic plateaus	TDEG	Mar.–Apr.	E, CR	SUK-SPG 1718
* <i>Brachystelma naorjii</i> Tetali & al.	Hill slopes	TDEG	May–June	E, CR	SUK-SPG 2020
Apocynaceae					
* <i>Ceropegia anantii</i> Yadav, Sardesai & Gaikwad	Hill slopes	TDEG	Aug.–Oct.	E, CR	SUK-SPG 1713
* <i>Ceropegia anjanerica</i> Malpure, Kamble & Yadav	Slopes in deciduous forests	TDEG	Sept.–Oct.	E, NE	SUK-SPG 2057
<i>Ceropegia attenuata</i> Hook.	Exposed rocky areas on hill tops/ slopes at 100–300 m alt.	TDEG	July–Sept.	E, LC	SUK-SPG 1003
<i>Ceropegia bulbosa</i> Roxb. var. <i>bulbosa</i>	Near bushes on slopes	TG	July–Oct.	NE	SUK-SPG 1044
<i>Ceropegia bulbosa</i> Roxb. var. <i>lushii</i> (Grah.) Hook. f.	Near bushes on slopes	TG	July–Oct.	NE	SUK-SPG 1300
* <i>Ceropegia concanensis</i> Kamble, Chandore & Yadav	Exposed rocky areas on hill tops/ slopes 100 m alt.	TDEG	July–Sept.	E, NE	SUK-SPG 1410
* <i>Ceropegia evansii</i> McCann.	In bushes of <i>Carvia callosa</i> (Nees) Bremek. on hill slopes at 1,000–1,200 m alt.	TG	July–Oct.	E, CR	SUK-SPG 1213
* <i>Ceropegia fantastica</i> Sedgw.	Near bushes on lateritic plateaus from 100 to 1,000 m alt.	TG	Aug.–Sept.	E, CR	SUK-SPG 1399
<i>Ceropegia hirsuta</i> Wight. & Arn.	Hill slopes/grasslands	TG	July–Nov.	NE	SUK-SPG 1228
* <i>Ceropegia huberi</i> Ansari	In crevices of wet hanging rocks at 1,000–1,200 m alt.	TG	July–Aug.	E, CR	SUK-SPG 2857
* <i>Ceropegia jainii</i> Ansari & Kulk.	In crevices of rock on lateritic plateaus of 800–1,200 m alt.	TDEG	Aug.–Nov.	E, EN	SUK-SPG 2323
* <i>Ceropegia lawii</i> Hook. f.	Exposed hill tops and slopes	TDEG	Aug.–Sept.	E, EN	SUK-SPG 990
* <i>Ceropegia maccannii</i> Ansari	Exposed hill slopes	TDEG	July–Oct.	E, CR	SUK-SPG 2690
* <i>Ceropegia mahabalei</i> Hem. & Ansari	Gravelly hill tops and slopes at 800 m alt.	TDEG	Aug.–Sept.	E, CR	SUK-SPG 1818
* <i>Ceropegia media</i> (Huber) Ansari	In open forests and hill slopes	TG	July–Oct.	E, VU	SUK-SPG 1133
* <i>Ceropegia mohanramii</i> Yadav, Gawade & Sardesai	In open forests and hill slopes	TDEG	July–Nov.	E, NE	SUK-SPG 1663
* <i>Ceropegia noorjahanianae</i> Ansari	Amidst in grasses on wet margins of streams/hill slopes	TDEG	July–Aug.	E, VU	SUK-SPG 2314
<i>Ceropegia oculata</i> Hook.	Open forests	TG	July–Sept.	E, LC	SUK-SPG 1610
* <i>Ceropegia panchganiensis</i> Blatt. & McCann.	Open hill slopes at 1,000–1,200 m altitude	TDEG	July–Aug.	E, CR	SUK-SPG 2471
* <i>Ceropegia rollae</i> Hem.	Hill tops and slopes	TDEG	Aug.–Oct.	E, CR	SUK-SPG 2955
* <i>Ceropegia sahyadrica</i> Ansari & Kulk.	Hill slopes at 1,000–1,200 m altitude	TDEG	July–Sept.	E, VU	SUK-SPG 1996
* <i>Ceropegia santapau</i> Wadhwa & Ansari	Hill slopes at 1,000–1,200 m altitude	TG	July–Aug.	E, CR	SUK-SPG 1319
* <i>Ceropegia vincifolia</i> Hook.	Among bushes in open forests 800–1,200 m alt.	TG	July–Sept.	E, VU	SUK-SPG 1722
Convolvulaceae					
* <i>Merremia Rhyncorrhiza</i> (Dalz.) Hall. f.	Crevice of rocks at 1,000 m altitude	TG	July–Nov.	E, EN	SUK-SPG 1305
Apiaceae					
<i>Heracleum aquilegifolium</i> C.B. Cl.	Gravelly hill slopes 800–12,00 m alt.	TDEG	Sept.–Nov.	E, LC	SUK-SPG 2244
<i>Heracleum dalgadianum</i> Almeida	Gravelly hill slopes 800–1,200 m alt.	TDEG	Aug.–Nov.	E, LC	SUK-SPG 994
<i>Peucedanum dhana</i> C.B. Cl. var. <i>dalzellii</i> C.B. Cl.	Gravelly hill slopes 800–1,200 m alt.	TDEG	July–Aug.	NE	SUK-SPG 3000
* <i>Pinda konkanense</i> (Dalz.) Mukh. & Const.	Gravelly hill slopes 800–1,200 m alt.	TDEG	July–Sept.	E, LC	SUK-SPG 2725
* <i>Polyzygos tuberosa</i> Dalz.	Gravelly hill slopes 800–1200 m alt.	TDEG	July–Sept.	E, VU	SUK-SPG 1515



Figure 2. (A) *Ceropegia evansii*; (B) *Ceropegia fantastica*; (C) *Ceropegia santapau*; (D) *Ceropegia maccannii*; (E) *Ceropegia panchganiensis*; (F) *Ceropegia sahyadrica*; (G) *Ceropegia jainii*; (H) *Ceropegia noorjahaniae*; (I) *Ceropegia vincifolia*. Photos: S.P. Gaikwad 2010.



Figure 3. (A) *Ceropegia huberi*; (B) *Ceropegia bulbosa* var. *lusii*; (C) *Ceropegia media*; (D) *Ceropegia mahabalei*; (E) *Brachystelma malwanense*; (F) *Euphorbia fusiformis*; (G) *Flemingia nilgherinsis*; (H) *Begonia concanensis*; (I) *Merremia rhyncorrhiza*. Photos: S.P. Gaikwad 2010.

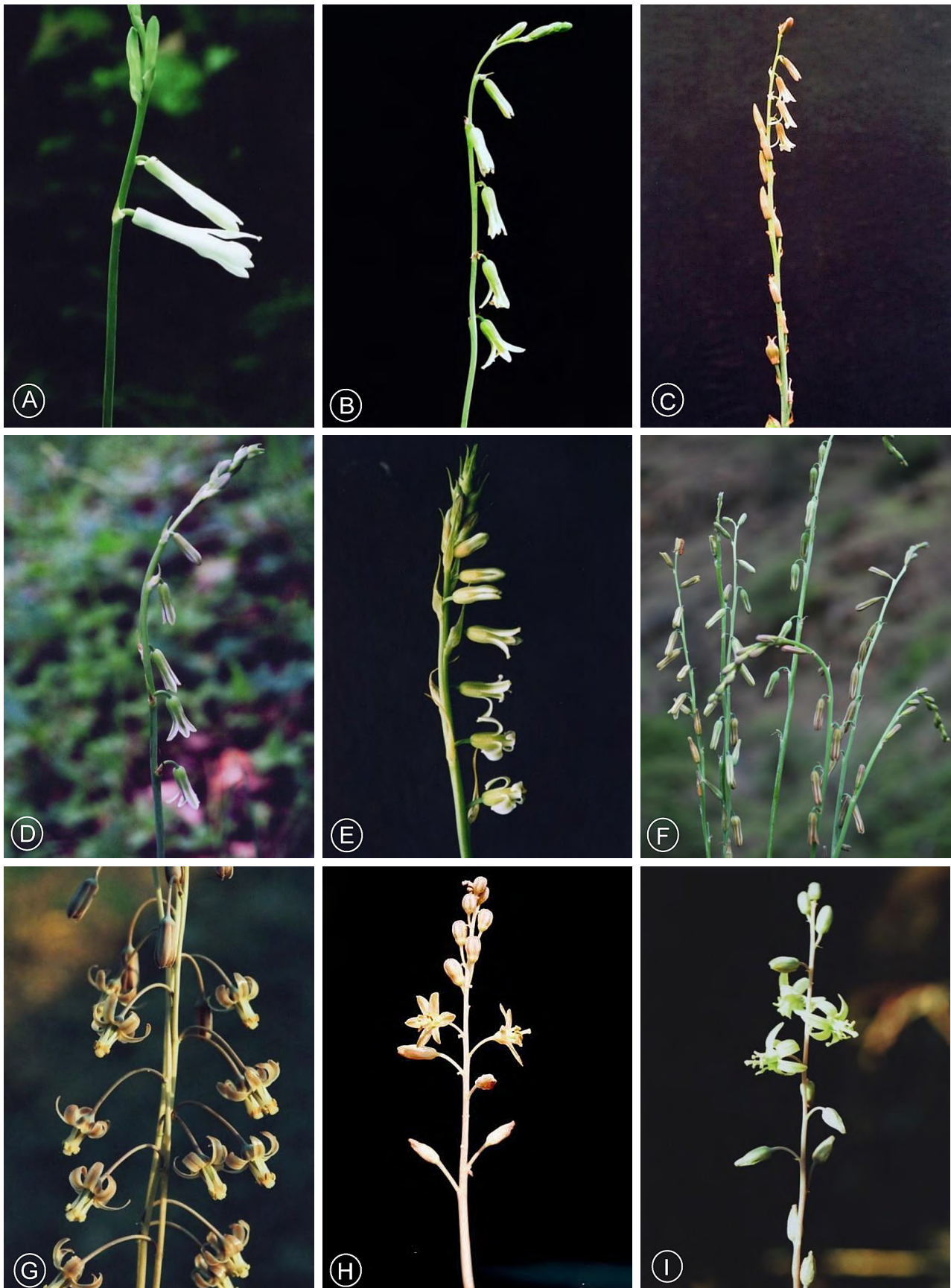


Figure 4. (A) *Dipcadi concanense*; (B) *Dipcadi ursulae* var. *ursulae*; (C) *Dipcadi minor*; (D) *Dipcadi maharashtrense*; (E) *Dipcadi ursulae* var. *longiracemose*; (F) *Dipcadi saxorum*; (G) *Drimia indica*; (H) *Drimia razii*; (I) *Drimia polyantha*. Photos: S.P. Gaikwad 2010.



Figure 5. (A) *Drimia congesta*; (B) *Camptorrhiza indica*; (C) *Iphigenia stellata*; (D) *Iphigenia indica*; (E) *Iphigenia magnifica*; (F) *Chlorophytum kolhapurense*; (G) *Chlorophytum borivillianum*; (H) *Chlorophytum breviscapum*; (I) *Chlorophytum tuberosum*. Photos: S.P. Gaikwad 2010.



Figure 6. (A) *Scilla hyacinthiana*; (B) *Gloriosa superba*; (C) *Curcuma neilgherrensis*; (D) *Curcuma pseudomontana*; (E) *Hitchenia caulina*; (F) *Zingiber neesatum*; (G) *Zingiber purpureum*; (H) *Tacca leontopetaloides*; (I) *Costus speciosus*. Photos: S.P. Gaikwad 2010.



Figure 7. (A) *Aponogeton bruggenii*; (B) *Aponogeton satarensis*; (C) *Curculigo orchoides*; (D) *Crinum brachynema*; (E) *Crinum viviparum* var. *viviparum*; (F) *Crinum latifolium*; (G) *Cyanotis tuberosa*; (H) *Typhonium trilobatum*. Photos: S.P. Gaikwad 2010.



Figure 8. (A) *Arisaema leshenaultii*; (B) *Arisaema sahyadricum* var. *sahyadricum*; (C) *Arisaema murrayi*; (D) *Amorphophallus commutatus*; (E) *Amorphophallus konkanensis*; (F) *Amorphophallus paeoniifolius*; (G) *Ariopsis peltata*; (H) *Arisaema tortuosum* var. *neglectum*. Photos: S.P. Gaikwad 2010.

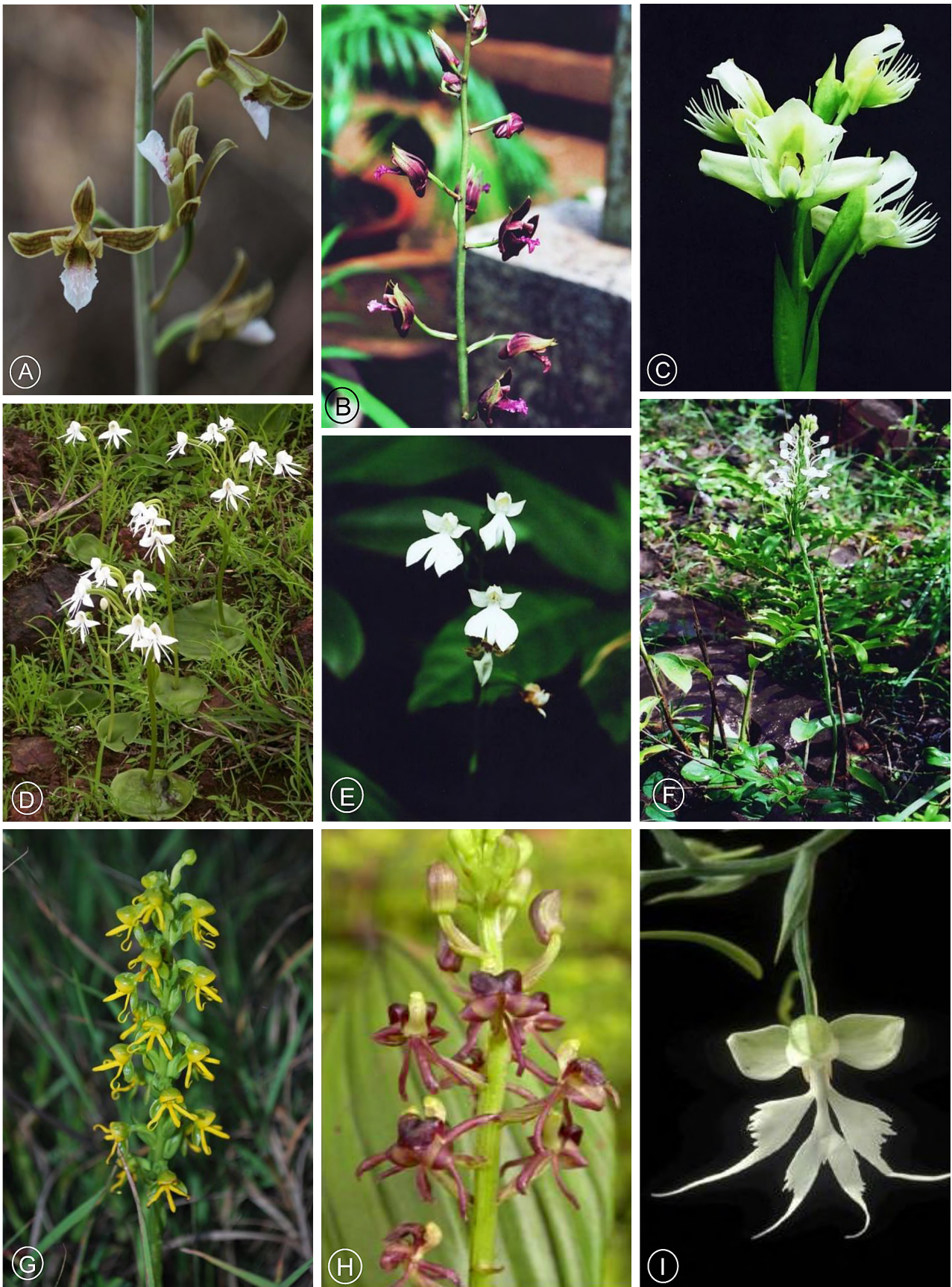


Figure 9. (A) *Eulophia graminea*; (B) *Eulophia nuda*; (C) *Pecteilis gigantea*; (D) *Habenaria panchganiensis*; (E) *Habenaria plantaginea*; (F) *Habenaria roxburghii*; (G) *Habenaria marginata* var. *marginata*; (H) *Liparis nervosa*; (I) *Habenaria crinifera*. Photos: S.P. Gaikwad 2010.