THREATENED ORCHIDS OF MAHARASHTRA: A PRELIMINARY ASSESSMENT BASED ON IUCN REGIONAL GUIDELINES AND CONSERVATION PRIORITISATION

Jeewan Singh Jalal and Paramjit Singh[1]

Botanical Survey of India, Western Regional Centre, Pune- 411 001, Maharashtra, India
[1]Botanical Survey of India, Headquarters, CGO Complex, Kolkata – 700 064, India

Abstract

The Maharashtra state lies between the latitudes 22°1' to 16°4' N and longitudes 72°6' to 80°9' E. spreading in an area of 307,731 km^2; it accounts for about 9.84 per cent of the total landmass of the country. Extensive field surveys of orchids were conducted during 2011-2014 in various parts of the state. A preliminary regional assessment was carried out using regional guidelines in accordance with the IUCN Red List criteria 3.1. A total of 101 orchid species were assessed of which 6 species are considered to be Possibly Extinct (PE), 7 species are categorised as Critically Endangered (CR), 7 species are Endangered (EN), 24 species as Vulnerable (VU), 25 species are considered Near Threatened (NT), 23 species are at Least Concern (LC) and 9 species are considered as Data Deficient (DD). In the present study thirty eight species of the orchids are reported as Threatened (CR, EN, VU). The main current threats are habitat degradation, mining and stone quarrying, over-grazing and trampling, windmills, invasive species, tourism, landslide, fire, over collection and drought. Three protected areas (Koyna WLS, Chandoli NP and Radhanagari WLS) are recommended for the *in situ* conservation.

Introduction

THE BIODIVERSITY across the planet is facing a rapid decline due to various threat factors which include habitat loss or degradation, over-exploitation, biological invasions, industrialisation, pollution and accelerated climate change. As a result of these anthropogenic activities, the rate of plant extinction has reached to 137 species per day (Moram *et al.*, 2011). During the second half of the 20th century, species extinction rates reached an almost unprecedented level in Earth's history (Frankham, 2003). This rate is considered to be 1000–10,000 times faster than the one it could naturally occur (Hilton-Taylor, 2000) and a trend which may result in the disappearance of between 60,000 and 1,00,000 plant species during the next 50 years (Akeroyd, 2002; Bramwell, 2002). The Convention on Biological Diversity (CBD) in which India is a signatory aims to conserve biodiversity, sustainable use of its components and share the benefits arising from the utilization of genetic resources in a fair and equitable way. The Global Strategy of Plant Conservation (GSPC) was adopted by CBD at its sixth conference of the parties. The long-term objective of the GSPC is to halt the continuing loss of plant diversity. The revised Global Strategy for Plant Conservation (GSPC) (2011–2020) calls for an assessment of the conservation status of all known plant species (target 2, UNEP, 2010).

The IUCN Red List of Threatened Species is recognised as the most comprehensive and objective global approach for evaluating the conservation status of plant and animal species. It is a widely recognized tool for identifying threatened species and offers a powerful method to identify priority sites for protection by providing information on the conservation status of species in the wild (Rodrigues *et al.,* 2006). The red list data constitutes a source of information that is essential to guide conservation efforts focussed on species. It is probably the best tool for estimating the current levels of biodiversity and trying to judge whether biodiversity levels increase or decrease in the future. IUCN Red list categories and criteria 1994 and 2001 were planned for the assessment of extinction threat of the species at the global level. Over the last decade, there has been growing interest in countries using the IUCN Red List Categories and Criteria at local and regional levels because it is the regional scale where the anthropological actions and biodiversity strike (Pimm *et al.*, 2001). The regional or national threat lists play a significant role in enlightening global preservation efforts, particularly when the information that they contain is integrated into the global IUCN Red List (Cuaron, 1993; Rodriguez *et al.*, 2000). In response to this interest, IUCN developed guidelines on how to apply the IUCN Red List Criteria appropriately for sub-global level assessments. Since the first version of the Guidelines for Application of the IUCN Red List Criteria at Regional Levels was

published in 2003 (version 3.0), these guidelines have been reviewed. In 2012, the guidelines for application of the IUCN Red List Criteria at Regional and National Levels (version 4.0) was released. The extinction risk of a species can be assessed at global, regional or national level. One species can have a different category in the Global Red List and a Regional Red List. For example, taxa that is common worldwide and classified as Least Concern (LC) in the Global Red List might be Endangered (EN) in a particular region. Red listing is not an end in itself but provides a comparative framework for conservation planning (Given, 2003).The application of the IUCN Red List Criteria at the regional level is a scientific and objective process for assessing how likely a species is to go extinct from a particular region.

Orchids are regarded as the flagship species in plant conservation, although sadly many species are being driven to extinction by either direct or indirect human activities. The state of Maharashtra harbours 101 orchid species. Many species are threatened with extinction either directly through loss of habitat or due to reasons such as degradation, fragmentation, over-collection etc. The aim of this article is to provide the preliminary red list assessment of orchids of Maharashtra at regional level. We hope that such regional assessment will be definitely beneficial for conservation planning at regional level as well as at national level.

Materials and Methods

Study Area

The state Maharashtra lies in the Western and Central part of the country between the latitudes 22°1' to 16°4' N and longitudes 72°6' to 80°9' E. It is bordered by Gujarat and the Union territory of Dadra and Nagar Haveli to the NorthWest, Madhya Pradesh to the North and NorthEast, Chhattisgarh to the East, Karnataka to the South, Telangana to the SouthEast and Goa to the SouthWest. It occupies an area of 307,731 km², which accounts for about 9.84 per cent of the total area of the country. The altitude ranges from sea level to 1646 msl. It comprises 35 districts and physiographically, this state may be divided into three natural divisions - the coastal strip (the Konkan), the Sahyadri or the Western Ghats and the Plateau. Over 80 % region of the state is occupied by Deccan Plateau. Tapi, Godavari, Bhima and Krishna are the main rivers of the state. This state has a tropical monsoon climate. Over 90% of the rainfall is due to South-Western monsoon (June to September). There is heavy rainfall in the coastal region (about 2000 mm),

scanty rains in the rain shadow areas in the central parts (about 500 mm) and medium rains in the eastern parts (about 1000 mm) of the state. As per Champion and Seth (1968), the State has 16 forest types which belong to six forest type groups i.e., Tropical Semi-Evergreen, Tropical Moist Deciduous, Littoral and Swamp, Tropical Dry Deciduous, Tropical Thorn and Subtropical Broad leaved Hill Forests.

Species Coverage

A total 101 species belonging to 33 genera were assessed. Of these 51 species are terrestrial, 49 epiphytic and one myco-heterotrophic. In Maharashtra, the total endemic orchid species are 36 spread over in 12 genera. Of these 25 species are endemic to Western Ghats i.e., Bulbophyllum fimbriatum (Lindl.) Rchb.f., Conchidium exile (Hook.f.) Ormerod, C. filiforme (Wight) Rauschert, C. microchilos (Dalzell) Rauschert, Dendrobium aqueum Lindl., D. barbatulum Lindl., D. lawianum Lindl., D. microbulbon A. Rich., D. nanum Hook.f., D. nodosum Dalzell., D. ovatum (L.) Kraenzl., Gastrochilus flabelliformis (Blatt. & McCann) C.J. Saldanha, Habenaria elwesii Hook.f., H. foliosa A. Rich., H. heyneana Lindl., H. multicaudata Sedgw., H. ovalifolia Wight, H. perrottetiana A. Rich., H. rariflora A. Rich., H. suaveolens Dalzell, Pinalia mysorensis (Lindl.) Kuntze, P. polystachya (A.Rich.) Kuntze, Smithsonia maculata (Dalzell) C.J.Saldanha, S. straminea C.J. Saldanha and S. viridiflora (Dalzell) C.J. Saldanha, 4 species are endemic to Peninsular India i.e., Eulophia pratensis Lindl., Habenaria brachyphylla (Lindl.) Aitch., H. gibsonii Hook.f. and H. grandifloriformis Blatt. & McCann and 7 species are Indian endemic i.e., Aerides crispa Lindl., A. maculosa Lindl., Conchidium reticosum (Wight) Ormerod, Eulophia ochreata Lindl., Habenaria hollandiana Santapau, H. longicorniculata J. Graham and Porpax jerdoniana (Wight) Rolfe.

Data Collection

The present work is the result of extensive and intensive field explorations undertaken during the period 2011 to 2014 at different regions of Maharashtra. Prior to the field survey, a tentative list of species occurring in Maharashtra was prepared based on standard literature. The information collected was used to draft the preliminary distribution of these species, as well as to plan the time table for field studies. The geographical co-ordinates of each location were recorded during the field survey using Global Positioning System (GPS model Garmin etrex). A total of 517 GPS readings were recorded in the field and simultaneously 1641 occurrence records were

collected from different herbaria (CAL, BSI, BLAT, SUK). The period of these herbarium data collections range from the year 1888 to 2014. Records lacking geographic coordinates on specimen labels were geo-referenced using topographic maps and online mapping tools such as Google Earth or GEOLocate.

During field surveys, when a population of orchids was located, the size, the extent, the habit, the habitat, the altitude and the life forms were recorded. Mature individuals were also counted in each locality for assessing the status of the species, only those individuals which bear flowers or fruits were counted as mature (IUCN, 2010). Direct observations were made to determine the potential and actual threats to the orchid population in Maharashtra. Various threats that were observed include habitat destruction, modification and fragmentation of natural habitats, encroachments, tourism activities, windmills, mining and stone quarrying, illegal collection for medicinal purpose, grazing, fire, invasive species, and natural disasters.

IUCN Categories and Criteria

There are nine clearly defined categories [Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD) and Not Evaluated (NE)] of IUCN to categorise any known taxa in the world. Extinct means that there is no reasonable doubt that the last individual has died. Extinct in the Wild means that the taxon is extinct in its natural habitat. Species under the CR, EN and VU categories are all considered as "threatened" and are a conservation priority. The category Near Threatened is applied to taxa that do not qualify for CR, EN and VU, but is close to qualifying for or is likely to qualify for a threatened category in the near future. The category Least Concern is applied to taxa that do not qualify for CR, EN, VU and NT. Widespread and abundant taxa are included in this category. The category Data Deficient highlights taxa for which sufficient information is lacking to make a sound assessment status. The category Not Evaluated applies to taxa that have not yet been evaluated against the Red List Criteria.

The IUCN has framed five quantitative Red Listing Criteria (A: Population size reduction, B: Geographic range, C: Small population size and decline, D: Very small or restricted population, E: Quantitative analysis) to determine whether a taxon is threatened or not. Any one or all of these criteria can be used to assign the threat category (IUCN, 2001, 2012). These criteria are based around the biological indicators of populations that are threatened with extinction, such as rapid population decline or very small population size. Most of the criteria also include sub-criteria that must be used to justify more specifically the listing of a taxon under a particular category.

For regional assessment, the IUCN Red List Categories and Criteria will be same as global but with three exceptions or adjustments. One, taxa extinct within a particular region but extant in other parts of the country is classified as Regionally Extinct (RE). The category Regionally Extinct (RE) is used when no reasonable doubt that the last individual has died. Listing of a species as 'Regionally Extinct' requires exhaustive surveys in all known or likely habitats. The tag of 'Possibly Extinct' has therefore been developed to identify those Critically Endangered species that are likely disappeared from the region, but for which confirmation required (IUCN, 2010). Possibly Extinct is a tag and not a new Red List category. In the present assessment for such species the tag 'Possibly Extinct (PE)' was used. Two, the category of Extinct in the Wild (EW) should be assigned only to taxa that are extinct in the wild across their entire natural range, including the region, but that are extant in cultivation, in captivity, or as a naturalized population (or populations) outside the past range. If a taxon is (globally) EW but extant as a naturalized population within the region, the regional population should not be evaluated according to the IUCN Criteria, but should still be considered of conservation importance and preserved as a relict of a taxon which is Extinct in the Wild. It may also be considered an important source of individuals for re-introduction efforts within its natural range. There is no such taxon present in the state. Three, taxa not eligible for assessment at the regional level (mainly introduced taxa and vagrants) should be assigned the category Not Applicable (NA). The addition of the categories Regionally Extinct (RE) and Not Applicable means that there are 11 possible categories for regional assessments (Fig. 1a). A brief description of the IUCN categories B & D (except A,C and E) which were used in the assessment of present study for orchids of Maharashtra is provided in the Table 1a. Criteria A, C and E were not used for the assessment because there were no data on defined rate of population decline coupled with the small population size.

Regional Conservation Assessment

The regional assessment was carried out in a three-step process. The first step begins to determine which taxa (Orchidaceae) and which regional populations
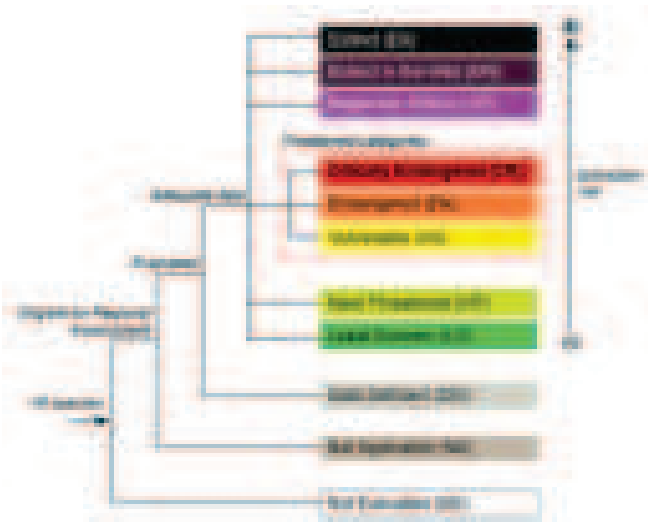
Fig. 1a. IUCN Red List Categories at regional scale (IUCN, 2012).

(Maharashtra state) to assess (step one). Next, the regional population for each taxon is evaluated according to the IUCN Red List Categories and Criteria Ver. 3.1 (IUCN 2001, 2012), and a preliminary category is assigned (step two). The effect of populations of the same taxon in neighboring regions on the regional population is then considered and the preliminary category is down-listed if appropriate (step three). If the taxon is endemic to the region or if the regional population of a species to be assessed is isolated from conspecific populations outside the region, the criterion is used without modification. Adjustments can be made to all the categories except for Extinct (EX), Extinct in the Wild (EW), Regionally Extinct (RE), Data Deficient (DD), Not Evaluated (NE), and Not Applicable (NA), which cannot logically be up- or down-listed. Taxa that have been down-listed in the regional Red List is clearly indicated by a degree sign after the category (*e.g.*, EN°, VU°).

Calculation of Area of Occupancy (AOO) and Extent of Occurrence (EOO)

Range size, according to IUCN, is measured as extent of occurrence (EOO, the smallest polygon in which no internal angle exceeds 180^0 and contains all sites of occurrence) and as area of occupancy (AOO, the area occupied by taxon, excluding cases of vagrancy, at a scale appropriate to the taxon). These two measures
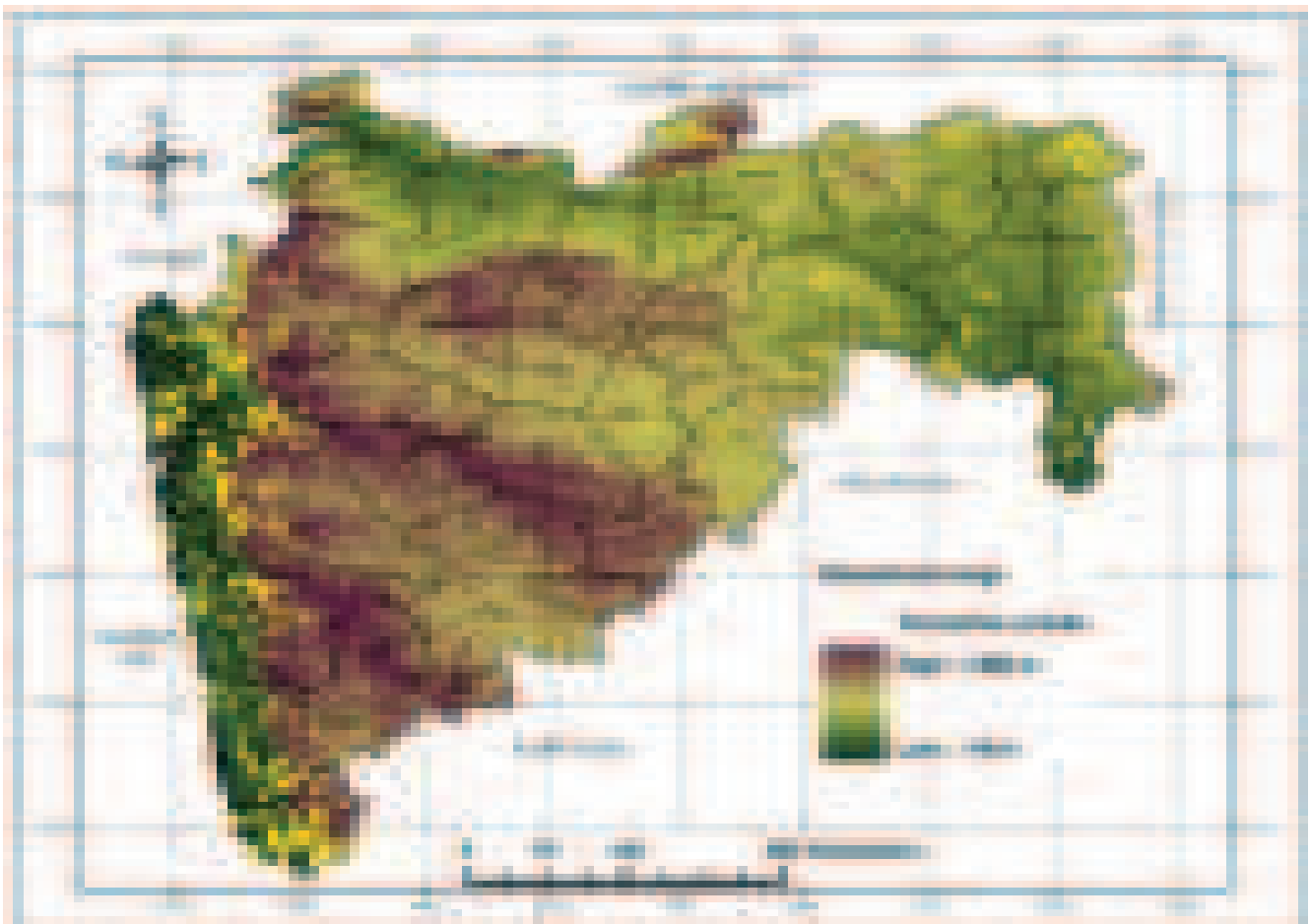

Fig. 1b. Distribution of terrestrial orchids in Maharashtra.

Table 1a. IUCN threat categories and Criteria (B and D) applied to the regional assessment of orchids in Maharashtra.

B. Geographic range in the form of either B1 (extent of occurrence) and/or B2 (area of occupancy)			
	Critically Endangered	Endangered	Vulnerable
B1. Extent of occurrence (EOO)	< 100 km²	< 5,000 km²	< 20,000 km²
B2. Area of occupancy (AOO)	< 10 km²	< 500 km²	< 2,000 km²
AND at least 2 of the following conditions:			
a) Severely fragmented, OR Number of locations	1	< 5	< 10
b) Continuing decline in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals.			
c) Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals.			

	Critically Endangered	Endangered	Vulnerable
D. Number of mature individuals	<50	<250	D1. <1,000
D2. Only applies to the VU category Restricted area of occupancy or number of locations with a plausible future threat that could drive the taxon to CR or EX in a very short time.			D2. typically: AOO<20km² or number of locations < 5

are the foundation of the 'B' criterion of the IUCN Red List system (IUCN 2001). EOO provides information on overall geographical spread while AOO provides information on the area of suitable habitat. Both EOO and AOO were calculated using the Geospatial Conservation Assessment Tool (GeoCAT; Geospatial Conservation Assessment Tool), developed by Royal Botanic Gardens, Kew. All the occurrence data of a particular species was prepared in the spreadsheet and this data import was directly done to the GeoCAT tools. Based on the location points, the extent of occurrence (EOO) and area of occupancy (AOO) values are instantly calculated and the values were compared with the thresholds set in the IUCN Criteria.

Results and Discussion

Distribution Pattern

The distribution of orchids in Maharashtra is patchy and concentrated in the high rainfall areas such as Khandala-Lonavala, Mahabaleshwar-Koyna-Chandoli, Amboli and Radhanagari. As a whole, orchids are concentrated mainly in the Western Ghats of Maharashtra (>80 species) and lowest in the Deccan peninsula. Among different life forms, the epiphytic orchids showed the same pattern, whereas the few species of terrestrial orchids were found distributed in the Deccan plateau (Figs.1b,2). Rainfall is one of the major climatic factors that affects the distribution of vegetation at a regional scale. The Western Ghats Mountain Range is very tall and blocks the moisture

from the SouthWest monsoon and hence the Deccan Plateau region receives very little rainfall. Due to high mountains of Western Ghats, the rainfall decreases Northwards and Eastwards. The semi-arid region of Deccan plateau only supports few terrestrial species *i.e., Eulophia graminea* Lindl, *Eulophia pratensis* Lindl., *Habenaria commelinifolia* (Roxb.) Wall. ex Lindl., *Habenaria digitata* Lindl., *Habenaria gibsonii* Hook.f. and *Habenaria roxburghii* Nicolson and that too, mainly in rainy season. However, in marshy localities and near dam side, *Zeuxine strateumatica* (L.) Schltr. is also seen growing in the winter season. *Peristylus constrictus* (Lindl.) Lindl. is distributed in Satpura range of Toranmal and Melghat areas in Maharashtra. Epiphytic orchids such as *Luisia trichorhiza* (Hook.) Blume and *Vanda tessellata* (Roxb.) Hook. ex Don are also reported from this range. Majority of the endemic species are confined to selected hill tops or small hill areas of semi-evergreen forests, plateaus and moist deciduous forests, thus making those pockets very important with regard to conservation. Very few species are distributed in the central Maharashtra and Vidharba regions. This region falls under the rain shadow region. Endemic species such as *Aerides maculosa* Lindl., *Eulophia pratensis* Lindl., *Habenaria gibsonii* Hook.f. and *Habenaria grandifloriformis* Blatt. & McCann have very wide range of distribution. But their maximum abundance is in Western Ghats part of Maharashtra. To see the species richness along the altitudinal gradient, the state is divided into 100 m altitudinal zones for the sake of convenience. The overall distribution of orchids is shown in Fig. 3. There
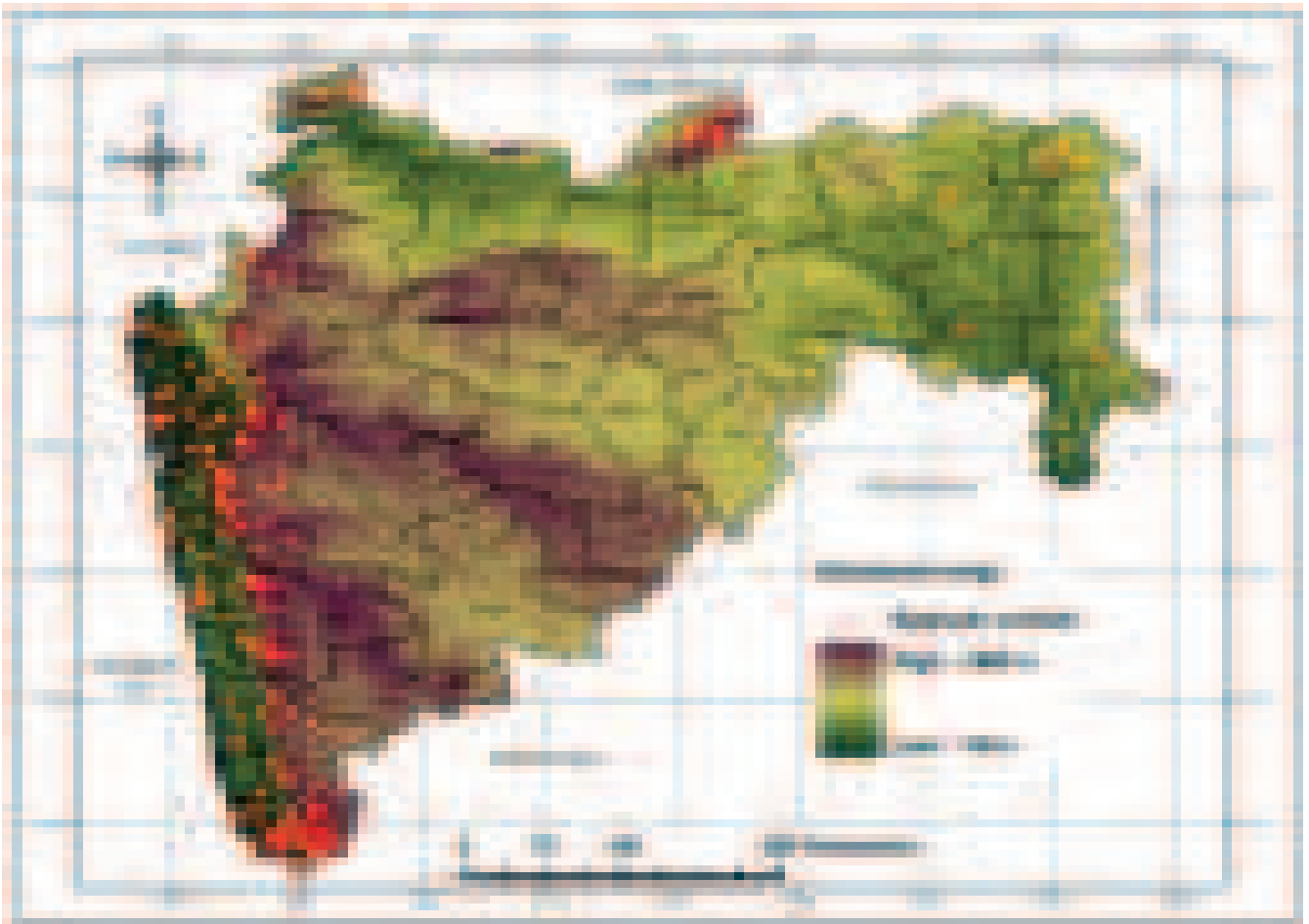
Fig. 2. Distribution of epiphytic orchids in Maharashtra.
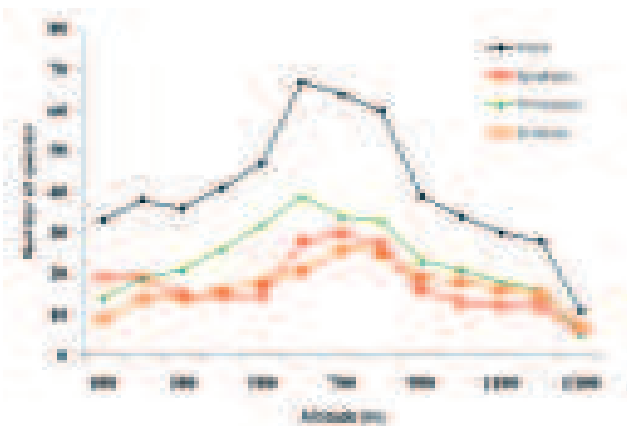
Fig. 3. Altitudinal distribution of orchids in Maharashtra.

is a significant increasing trend in the total species richness up to 600 m and after that it shows gradual decrease. Both the epiphytic and terrestrial orchids have their maximum richness in the 600 m altitude. Because of habitat heterogeneity, this altitude has maximum habitat support for orchids. However,

Fig. 4. Overall regional assessment status of orchids of Maharashtra.

endemic orchid species richness is more in the elevations of 700 to 800 m, because many endemic

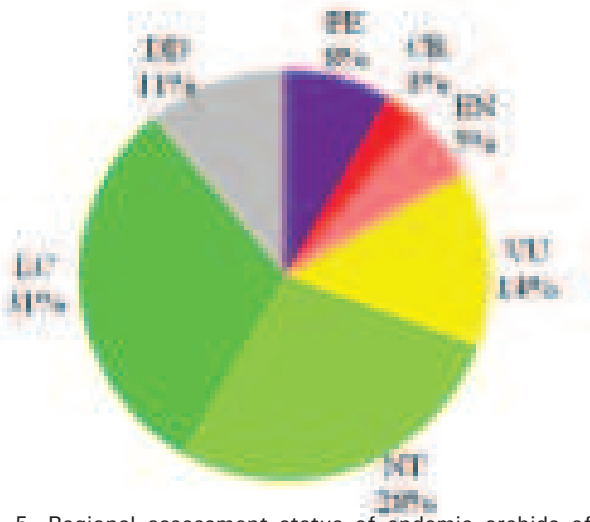Fig. 5. Regional assessment status of endemic orchids of Western Ghats in Maharashtra.

species are restricted to these altitudes; and they are distributed in high rainfall pockets.

IUCN Threat Status

The available data and assessment for all species are shown in Table 1b. The preliminary assessment shows that 38 species are in threatened category: 7 species are Critically Endangered, 7 Endangered and 24 Vulnerable. Within the Not Threatened categories, 23 species (23%) are classified as Least Concern, 25 species (24%) as Near Threatened, and 9 species (9%) as Data Deficient. A total of 6 species (6%) have been assessed as Possibly Extinct in Maharashtra (Fig. 4).

The localities of the seven Possibly Extinct species were thoroughly explored during the survey but could not be located in the field. The possibility could be that the population size may be alarmingly small or the species may be present outside the study area. Based on these possibilities, placement of the species under the category of Regionally Extinct (RE) is doubtful until a thorough survey is made in the adjacent areas also. Therefore, as recommended in "Guidelines for Using the IUCN Categories and Criteria (IUCN, 2010), these species are tagged as "possibly extinct" and further efforts should be made in order to confirm their actual conservation status.

Out of total 36 endemic species, 3(8%) species are Possibly Extinct, 1 (3%) species Critically Endangered, 2 (5%) species Endangered, 5 (14%) species Vulnerable, 10 (28%) species Near Threatened, 11 (31%) species Least Concern and 4 (11%) species Data Deficient (Fig. 5). The majority of the assessments used category 'B' that relates to the geographical range.

Orchids Vs Protected Areas

Maharashtra state has a total of 42 well established protected areas (PAs) including one conservation reserve, covering an area of approximately 18,730 km^2 which constitutes 6.08 per cent of the state's geographical area. The present field surveys and past records show that out of 42 PAs, only 16 protected areas harbour 50% of orchid species out of the total
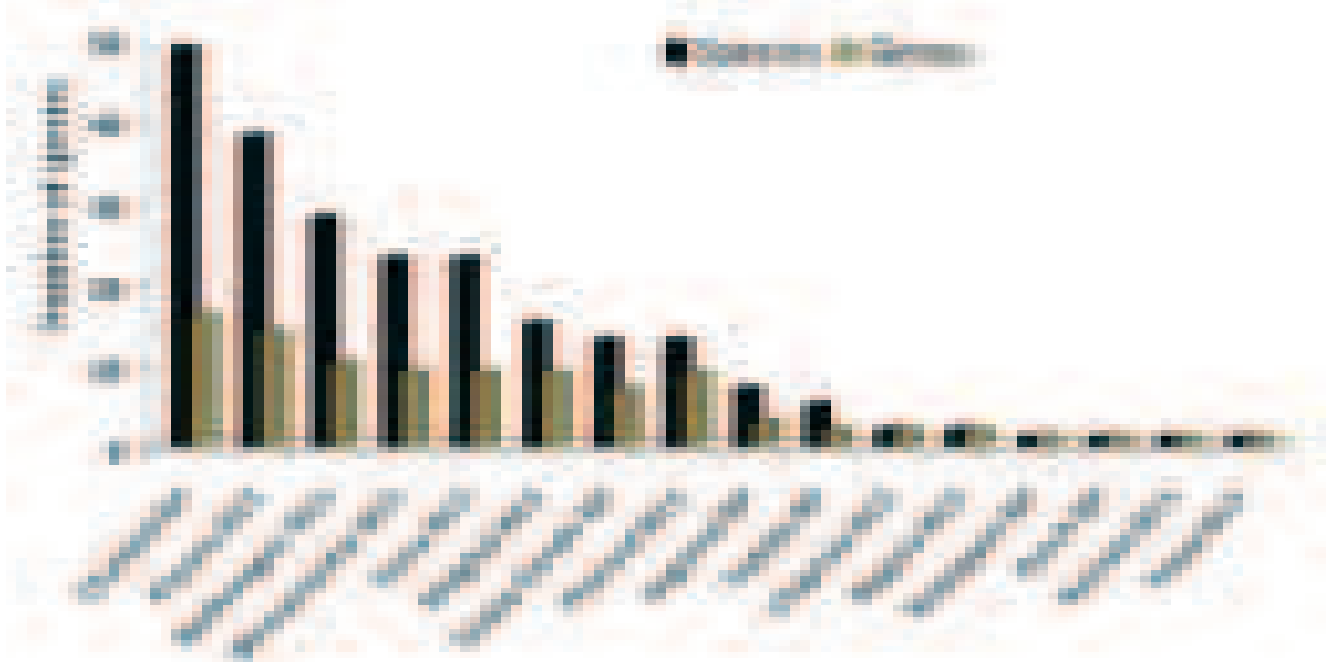

Fig. 6. Orchid species richness in the different PAs in Maharashtra.

Table 1b. Regional assessment of orchids of Maharashtra.

SL. No.	Species	Habit	EOO km²	AOO km²	Locations	Population (Total count of mature individuals)	Threat Category	Criteria	Threats
1	*Aerides ringens* (Lindl.) C.E.C.Fischer	E					PE		
2	*Habenaria viridiflora* (Rottler ex Sw.) Lindl.	T					PE		
3	*Pinalia mysorensis* (Lindl.) Kuntze	E					PE		
4	*P. polystachya* (A.Rich.) Kuntze	E					PE		
5	*Smithsonia maculata* (Dalzell) C.J.Saldanha	E					PE		
6	*Trias stocksii* Benth. ex Hook.f	E					PE		
7	*Cheirostylis flabellata* (A.Rich.) Wight	T		4	1		CR	B2ab(iii)	A
8	*Cleisostoma tenuifolium* (L.) Garay	E		4	1	Unknown	CR	B2ab(iii)	A
9	*Oberonia ensiformis* (Sm.) Lindl.	E		4	1		CR	B2ab(iii)	A
10	*O. mucronata* (D.Don) Ormerod & Seidenf.	E		4	1		CR	B2ab(iii)	A
11	*Pachystoma pubescens* Blume	T		4	1		CR	B2ab(iii)	A
12	*Smithsonia straminea* C.J.Saldanha	E		4	1	*ca.*210	CR	B2ab(iii); D	A
17	*Luisia tenuifolia* Blume	E		8	2		CR	B2ab(iii)	A
13	*Cheirostylis parvifolia* Lindl.	T	2,459.54	20	4	<150	EN	B1ab(i,ii,iii) + 2ab(i,ii,iii)	A
14	*Dendrobium nodosum* Dalzell	E	3,686.54	16	4	<200	EN	B1ab(i,ii,iii,iv) + 2ab(i,ii,iii,iv)	A
15	*Eulophia graminea* Lindl.	T		8	2	<10	EN	B2ab(ii,iii)	A, H, J
16	*E. epidendraea* (J.Koenig ex Retz.) C.E.C.Fisch.	T		8	2	Unknown	EN	B2ab(iii)	A, J
17	*E. pratensis* Lindl.	T	65,782.18	20	5	< 80	EN	B2ab(i,ii,iii)	C, E, H, I, J
18	*Peristylus aristatus* Lindl.	T	1,119.18	28	4	30	EN	B1ab(iii) + 2ab(iii)	C, F
19	*Zeuxine gracilis* (Breda) Blume	T	108.18	12	3	<15	EN	B1ab(iii) + 2ab(iii)	B
20	*Bulbophyllum sterile* (Lam.) Suresh	E		8	2	Unknown	VU°	B2ab(iii)	A
21	*Cymbidium bicolor* Lindl.	E		8	2	<100	VU°	D2	A
22	*C. aloifolium* (L.) Sw.	E	177.35	12	3	<500	VU°	B1ab(iii) + 2ab(iii)	A, H
23	*Dendrobium crepidatum* Lindl. & Paxton	E	9,363.89	32	5	<500	VU°	B2ab(i,ii,iii)	A
24	*D. macrostachyum* Lindl.	E	4,198.34	24	4	<600	VU°	B1ab(i,ii,iii,iv) + 2ab(i,ii,iii,iv)	A
25	*D. nanum* Hook.f.	E	8,326.85	20	5	<400	VU°	B2ab(ii,iii,v)	A
26	*D. peguanum* Lindl.	E	4,244.96	16	4	380	VU°	B1ab(i,ii,iii,iv) + 2ab(i,ii,iii,iv)	A, H
27	*Epipogium roseum* (D. Don) Lindl.	MH		8	2	8	VU°	B2ab(iii)	G
28	*Eulophia herbacea* Lindl.	T	1,492.95	12	3	Unknown	VU°	B1ab(i,ii,iii) + 2ab(i,ii,iii)	A, C, E, J
29	*E. ochreata* Lindl.	T	214,330.22	36	5	< 450	VU°	B2ab(i,ii,iii,iv); C2a(i)	A, C
31	*Geodorum densiflorum* (Lam.) Schltr.	T	94,140.10	20	5	80	VU°	B2ab(i,ii,iii,iv)	B, E
32	*Habenaria crinifera* Lindl.	T	3,729.04	36	8	<400	VU°	B1ab(iii) + B2ab(iii)	A
33	*H. multicaudata* Sedgw.	T	26,028.85	16	4	21	VU°	B2ab(iii); D	E, H
34	*H. stenopetala* Lindl.	T	6,910.37	20	3	<10	VU°	B2ab(i,ii,iii)	B, G
35	*H. suaveolens* Dalzell	T	15,979.10	40	8	<8000	VU	B1ab(i,ii,iii,v)	B, F
36	*Luisia trichorhiza* (Hook.) Blume	E	1,732.42	16	4	<100	VU°	B1ab(iii) + 2ab(iii)	A, H

Table 1b. Regional assessment of orchids of Maharashtra (contd.).

SL. No.	Species	Habit	EOO km²	AOO km²	Locations	Population (Total count of mature individuals)	Threat Category	Criteria	Threats
37	*Luisia tristis* Hook.f.	E	87,842.57	24	5	150	VU°	B2ab(ii,iii)	A, H
38	*Oberonia brunoniana* Wight	E	1,916.74	20	4	21	VU°	B1ab(iii) + 2ab(iii)	A
39	*O. falconeri* Hook.f.	E	56,063.45	16	3	<500	VU°	B2ab(i,ii,iii)	A
40	*Peristylus lawii* Wight.	T	109,380.57	20	4	350	VU°	B2ab(i,ii,iii)	B, E
41	*Pholidota imbricata* Lindl.	E		8	2	<250	VU°	B2ab(ii,iii); D	A
42	*Porpax jerdoniana* (Wight) Rolfe	E	8,773.13	20	5	<500	VU°	B2ab(ii,iii)	A
43	*Thunia alba var. bracteata* (Roxb.) N.Pearce & P.J.Cribb	E	3,590.66	20	5	<250	VU°	B1ab(iii) + 2ab(iii)	A
44	*Zeuxine longilabris* (Lindl.) Trimen	T	2,743.86	28	4	<350	VU°	B1ab(iii) + 2ab(iii)	B
45	*Bulbophyllum fimbriatum* (Lindl.) Rchb.f.	E	10,711.25	36	9	<3,000	NT°	B1ab(iii)	A, H
46	*Conchidium exile* (Hook.f.) Ormerod	E	8,592.16	32	7	*ca.*600	NT°		A
47	*C. reticosum* (Wight) Ormerod	E	17,189.50	72	15	<4000	NT		D, F
48	*Dendrobium aqueum* Lindl.	E	14,139.33	56	10	<3500	NT°	B2a(iii)	A, D
49	*D. herbaceum* Lindl.	E	22,518.39	52	11	<2500	NT		A
50	*D. lawianum* Lindl.	E	19,098.46	44	7	<3,000	NT°	B1ab(ii,iii)	A
51	*Eulophia spectabilis* (Dennst.) Suresh	T	257,270.14	72	12	2,700	NT		A, E, I
52	*Habenaria commelinifolia* (Roxb.) Wall. ex Lindl.	T	264,881.63	60	11	400	NT		G, J
53	*H. brachyphylla* (Lindl.) Aitch.	T	169,332.95	48	12	800	NT		B, F
54	*H. diphylla* (Nimmo) Dalzell	T	15,349.36	28	7	<500	NT°		B, C
55	*H. foliosa* A. Rich.	T	25,390.14	56	12	<500	NT		C, E, I
56	*H. furcifera* Lindl.	T	125,967.96	36	12	<380	NT		A, B
57	*H. ovalifolia* Wight.	T	36,470.29	56	12	<300	NT		A, F
58	*H. plantaginea* Lindl.	T	212,479.76	64	12	<700	NT		F, I
59	*H. rariflora* A. Rich.	T	34,545.25	72	15	<3000	NT		B, D, F, G
60	*H. roxburghii* Nicolson	T	64,178.19	24	6	< 300	NT		A, J
61	*Liparis odorata* (Willd.) Lindl.	T	17,895.21	60	11	<3500	NT		A
62	*Nervilia crociformis* (Zoll. ex Moritzi) Seidenf.	T	31,243.66	92	15	<11000	NT		A
63	*N. infundibulifolia* Blatt. & McCann	T	21,353.31	40	10	<5000	NT		A, G
64	*N. plicata* (Andrews) Schltr.	T	25,954.25	40	10	<4500	NT		A
65	*Peristylus densus* (Lindl.) Santapau & Kapadia	T	19,608.50	72	13	<4000	NT		B, C
66	*Porpax reticulata* Lindl.	E	12,310.93	56	11	<6000	NT		A, H
67	*Smithsonia viridiflora* (Dalzell) C.J.Saldanha	E	12,140.81	40	7	<400	NT°		A
68	*Zeuxine strateumatica* (L.) Schltr.	T	158,863.40	44	11	<5000	NT		A, J
69	*Acampe praemorsa* (Roxb.) Blatt. & McCann	E	37,391.54	120	25	<8,000	LC		A
70	*Aerides crispa* Lindl.	E	46,210.66	120	24	<4,000	LC		A, D

Table 1b. Regional assessment of orchids of Maharashtra (contd.).

SL. No.	Species	Habit	EOO km²	AOO km²	Locations	Population (Total count of mature individuals)	Threat Category	Criteria	Threats
71	*Aerides maculosa* Lindl.	E	174,700.97	156	32	<15,000	LC		A, D
72	*Conchidium filiforme* (Wight) Rauschert	E	30,997.35	104	21	<10,000	LC		A
73	*C. microchilos* (Dalzell) Rauschert	E	30,467.35	92	18	<7,000	LC		A
74	*Cottonia peduncularis* (Lindl.) Rchb.f.	E	33,484.89	72	18	<1500	LC		A, H
75	*Dendrobium barbatulum* Lindl.	E	74,101.72	140	29	<15,000	LC		A
76	*D. microbulbon* A. Rich.	E	26,262.48	80	18	<11,000	LC		A
77	*D. ovatum* (L.) Kraenzl.	E	35,274.79	104	21	<7500	LC		A, H
78	*Habenaria digitata* Lindl.	T	188,278.22	96	20	2,500	LC		B, C, E
79	*H. gibsonii* Hook.f.	T	210,108.10	128	27	<2000	LC		B, C
80	*H. grandifloriformis* Blatt. & McCann	T	170,109.82	124	24	<20000	LC		B, C, F
81	*H. heyneana* Lindl.	T	26,890.01	88	18	<3500	LC		B, C, F
82	*H. longicorniculata* J. Graham	T	136,219.18	92	17	<5000	LC		B, F, G
83	*H. marginata* Colebr.	T	297,032.34	140	28	<4000	LC		B, C
84	*Malaxis versicolor* (Lindl.) Abeyw.	T	34,006.46	88	17	<5000	LC		A
85	*Nervilia concolor* (Blume) Schltr.	T	213,330.46	96	19	<6000	LC		A
86	*Oberonia recurva* Lindl.	E	29,074.29	80	15	<10000	LC		A
87	*Pecteilis gigantea* (Sm.) Rafin.	T	207,315.23	88	15	<1000	NT		B, C, E, F,G
88	*Peristylus plantagineus* (Lindl.) Lindl.	T	284,961.53	92	18	<2500	LC		B
89	*P. stocksii* (Hook.f.) Kraenzl.	T	155,879.45	84	15	<4000	LC		A
90	*Rhynchostylis retusa* (L.) Blume	E	240,677.18	84	16	<3500	LC		A
91	*Vanda tessellata* (Roxb.) Hook. ex Don	E	63,234.29	52	16	<2500	LC		A
92	*V. testacea* (Lindl.) Rchb. f.	E	325,352.18	68	15	<1500	LC		A
93	*Diplocentrum recurvum* Lindl.	E					DD		
94	*Eulophia dabia* (D.Don) Hochr.	T					DD		
95	*Gastrochilus flabelliformis* (Blatt. & McCann) C.J. Saldanha	E					DD		
96	*Habenaria elwesii* Hook.f.	T					DD		
97	*H. hollandiana* Santapau	T					DD		
98	*H. perrottetiana* A. Rich.	T					DD		
99	*Oberonia bicornis* Lindl.	E					DD		
100	*Peristylus constrictus* (Lindl.) Lindl.	T					DD		
101	*Spiranthes sinensis* (Pers.) Ames	T					DD		

Abbreviations: E, Epiphytic; MH, Mycoheterotrophic; T, Terrestrial; PE, Possibly extinct; CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NT, Near Threatened; LC, Least Concern; DD, Data Deficient; A, Habitat degradation; B, Over-grazing and trampling; C, Mining and stone quarrying; D, Windmills; E, Invasive species; F, Tourism; G, Landslide; H, Fire; I, Over collection; J, Drought.

orchid species recorded in Maharashtra (Fig. 6). The best protected areas in terms of orchid species richness are Chandoli National Park with 49 species, Koyna Wildlife Sanctuary with 38 species, and Radhanagari Wildlife Sanctuary with 28 species. These protected areas can play a major role in protection of orchid diversity because within these areas, there is a restriction of collection of these species. Many PAs in Maharashtra are subject to both natural and human-induced disturbances at various scales. In recent decades, many of these have been heavily threatened by the spread of invasive alien plant species, notable among them being *Lantana* and *Eupatorium*. Mining industries are coming extremely closer to these PAs and some are even inside the PAs. Radhanagari WLS is one of the best PA for *in situ* orchid conservation but Indian Aluminium's (INDAL) Durgamanwad mine touches Radhanagari's northern boundary and affecting the habitat of rare and endemic orchids.

Major Threats to Orchids in Maharashtra

Major threats to orchids of Maharashtra include habitat degradation, mining and stone quarrying, over-grazing and trampling, windmills, invasive species, tourism, landslide, fire, over collection and drought. The graphical representation of each threat (Fig. 7) shows that 40% species are affected by habitat degradation. Destruction and fragmentation of natural habitats are the two most important factors in the current species extinction event. Although habitat destruction and degradation often appear to be the most immediate and significant effect, losses of unique evolutionary lineages and erosion of natural demographic and genetic processes associated with small population sizes as well as isolation are sure to be of consequence while considering the future of these populations (Coates, 2000).

Extension of townships, new construction on hills, creating accessibility to remote areas and 'modernisation' leading to change in life style are some noticeable threats throughout the Maharashtra. For example, private hill cities such as Aamby Valley, Lavasa, hill city *etc*. has caused damage to the natural habitat. Likewise, in Pashan lake near Pune, *Eulophia pratensis* (an endemic to Peninsular India) which was found abundant could not be located even after repeated search during this study period. This is due to expansive development of housing construction as a result of extension of Pune city. With increasing population, encroachment on forest land is a common practice. This has resulted in massive degradation of forest and illegal exploitation of resources. For example, the Yawal Wildlife Sanctuary in Jalgoan,

situated on the western part of the Satpura Mountain and bordering Madhya Pradesh is under heavy pressure from encroachers of Madhya Pradesh. This sanctuary is also important because it is a part of "Satpura Tiger landscape".

The decline in number of orchid species is reported from Panchgani, Kas Plateau, and Khandala. Kas plateau, known as the valley of flowers, is facing surge in tourists. Excited visitors pluck the orchids for their homes, leaving little chance for these rare orchids to survive. The fragrant *Pecteilis gigantea* popularly known as the queen of Khandala was found very commonly fifty years ago and sold in the Khandala hill station's markets. This led to a fall in the species and now it is confined to a few spots only. Likewise, *Habenaria suaveolens* Dalzell (popular synonym is *Habenaria panchganiensis*) known as Panchgani orchid, was once abundant in Panchgani plateau has now become a rare sight due to the tourism activities such as horse rides, camel rides that almost converted the flora rich plateau to a barren land. *Eulophia graminea* Lindl. is a rare orchid in Maharashtra, which is so far reported from Sangli and Osmanabad districts. Bachulkar and Yadav (1993) had reported this orchid from sugarcane fields near Islampur (Sangli district), where they had seen only two individuals. Conversion of land for agricultural purpose especially for cultivation of cash crops also causes depletion of orchid population as in the case mentioned above. In Konkan region of Maharashtra, many of the good forests patches have been cleared for cash crops such as Areca nut, Cashew nut, and mango orchard. The plateaus of Konkan are experiencing heavy pressures and disturbances due to their rapid conversion for settlements, paddy fields, orchards, quarries, grazing lands, windmill farms and industrialisation.

Mining is a rapidly growing threat to the orchid diversity across Maharashtra. Many areas of Northern
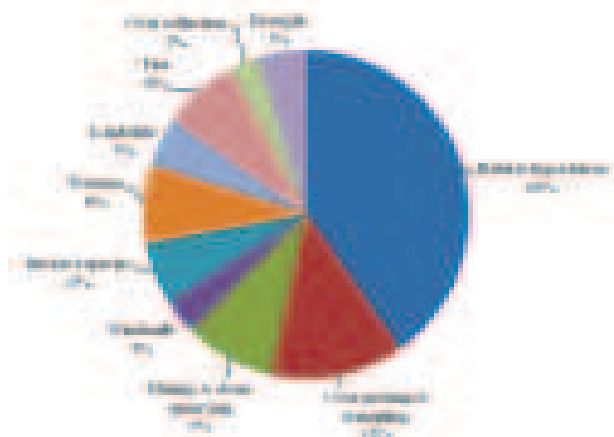

Fig. 7. Graphical representation of various threats levels.

Western Ghats of Maharashtra are heavily affected by Bauxite mining. Most of the mines are situated in the high altitude plateaus and dense evergreen forest areas above 800-1000 m.s.l. and consequentlt, the important habitat of orchids such as dense evergreen forests has been highly affected. Udgeri, Girgaon, Ringewadi, Dhangarwadi, and Manoli have their bauxite mines in the upper catchment in Warna river basin in Kolhapur district. These mines are very close to two protected areas like, Chandoli National Park and Radhanagari Wildlife Sanctuary. Such mining activities are proving to be detrimental to the last remaining wildlife habitats.

A large number of wind power projects have been commissioned on forest land in Maharashtra. Some of the key sites with optimal wind velocities are the plateaus on the Western Ghats. The rocky plateaus on the Western Ghats are terrestrial habitat islands facing extreme micro-environmental condition. These plateaus and hill sides are cut to make roads to transport heavy equipment for installing the windmills. This leads to erosion and landslides. Roads that are cut through forests and hills to enable movement of heavy-duty trailers lead to linear fragmentation of habitats. The ecological sensitive zones, plateaus and forest areas that support variety of terrestrial and epiphytic orchids in Bhimashankar Wildlife Sanctuary and Koyna Wildlife sanctuary in the northern part of the Western Ghats are facing habitat destruction due to roads, blasting and erosion as well as landslides after the monsoon with the rubble ending up in rivers and farmland below. The Western Ghats Ecology Expert Panel (WGEEP) says that according to forest department estimates, about 28,000 trees have been cut for the project (Bhushan *et al.*, 2013).

In Maharashtra, one can easily notice the local medicinal plant vendors in and around hill stations as well as near temples in the hilly regions. A variety of bulbous and tuberous plants collected from wild are sold in the name of its medicinal uses. For example, tubers of *Eulophia spectabilis* (Dennst.) Suresh, *Geodorum densiflorum* (Lam.) Schltr., *Malaxis versicolor* (Lindl.) Abeyw. are sold in the vicinity of temple in Bhimashankar WLS. *Eulophia spectabilis* Lindl. is a terrestrial orchid which is being extracted from wild leading to drastic depletion of wild populations. It is commonly known as *Amarkanda* and is widely used to cure various health problems and ailments. The corm of the plant is used in the preparation of 'salep', which is taken as an aphrodisiac (Jalal *et al.*, 2014). Since, the corm is collected by the local people, it has direct impact on the depletion of its population in wild.

Nearly 40 % of natural forest vegetation in Western Ghats has disappeared in the past 8-10 decades (Menon and Bawa, 1997). Spread of certain alien invasive weeds such as *Chromolaena odorata* (L.) R.M.King & H.Rob., *Mikania cordata* (Burm.f.) B.L.Rob., *Lantana camara* L. and *Parthenium hysterophorus* L. has led to encroachment of the habitat of ground orchids. As a consequence, it was observed that the population of orchids in many localities is on the decline. In many locations in Maharashtra, orchids are also facing threats due to landslides and floods in the rainy season.

Conservation Measures

The threat status of IUCN Red List provides an assessment of the extinction risk under current circumstances and it is not necessarily sufficient to determine priorities for conservation action. There are numerous other factors concerning conservation action such as costs, logistics, chances of success and other biological characteristics (Mace and Lande, 1991). However, assessment of taxa using Red List Criteria represents a critical first step in setting priorities for conservation action. In Maharashtra, areas such as Kaas plateau, Koyna Wildlife Sanctuary, Chandoli National Park and Radhanagari Wildlife Sanctuary have been included in the UNESCO list of natural world heritage sites which will help in conserving the natural habitats. But there is no such area which has been exclusively identified for orchid conservation. The following measures are suggested for long term orchid conservation in Maharashtra:

- 38 species, which are assessed as threatened in Maharashtra, need immediate action for conservation.

- Three protected areas (Koyna WLS, Chandoli NP and Radhanagari WLS) are recommended for the *in situ* conservation. Training on orchid identification and population monitoring should be provided to the staff of these PAs.

- Eco-Sensitive Zones (ESZ) *i.e.,* Mahabaleshwar-Panchgani and Matheran should be preferably looked upon as orchid conservation sites.

- Orchid rich localities outside the PAs *i.e.,* Amboli and Lonavala-Amby valley should be developed as orchid conservation areas (OCAs).

- Forest department, non-governmental organizations (NGOs), volunteers and local stake holders must undergo at least basic training in orchid identification and conservation.

- For *ex situ* conservation, there is a need to establish an orchid conservatory which can be used for training, rescue and vegetative propagations.

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