NELUMBO 54 : 29 - 38, 2012 ISSN 0976 5069

ALTITUDINAL DISTRIBUTION, HABITATS AND LIFE FORMS OF ORCHIDS OF WESTERN HIMALAYA

JEEWAN SINGH JALAL

Botanical Survey of India, Western Regional Centre
7 Koregaon Road, Pune- 411 001
E-mail:jeewansinghjalal@rediffmail.com

ABSTRACT

The study was carried out with the aim to know the distribution of orchids in different altitudinal zones, habitat types and life forms in the Western Himalaya. Extensive field data was collected from 2005 to 2010 and secondary data were acquired from various floras. The orchid species richness along the altitudinal zones shows a hump-shaped distribution pattern with high species richness in the middle altitudinal zone between 1000m to 1500m. A total of 18 habitat types were identified. Banj-oak forests and Riverine forests had the highest species richness. The highest similarity value (Sj = 74) was between habitat pairs Oak-Rhododendron life form was Moru-oak (OR- MO). Twelve different life forms were identified for orchids. The most abundant life-forms were the tuber geophytes and the fact that they are distributed in all the habitats, indicates high ecological plasticity.

Keywords: Western Himalaya, Orchids, Species richness, Habitats, life forms

INTRODUCTION

Elevational gradients, such as the Himalaya, can serve as an excellent system to evaluate ecological and biogeographical theories of species richness and their relationships to climate (Körner, 2000). Studies of several groups of organisms have identified pronounced variations in species richness along elevation gradient over a century (Pianka, 1966; Kessler, 2000; Lomolino, 2001). The geographical and climatic feature of a region determines the distribution of plant species. Lomolino (2001) pointed out that many components of climate and local environment (*e.g.,* temperature, precipitation, seasonality and disturbance regime) vary along the elevation gradients and ultimately create the variation in species richness. There is a great deal of variation in the altitude and topography of Western Himalaya. The average annual precipitation varies from east to west c. 200cm to 100cm. This eco-climatic variation has resulted in the development of a large number of habitat types. Orchids are known to grow in a wide range of habitats. However within a broad habitat, majority of the species require specific microclimate for their growth and regeneration. Several environmental factors are responsible for the distribution of orchids *e.g.*, climatic factors (suitable temperature and rainfall), edaphic factors (soil moisture, texture and pH) and local factors (micro-habitats). Although orchids are highly advanced group of flowering plants capable of occupying almost all possible ecological conditions and habitats, they are highly vulnerable to slight change in the environmental conditions. Most of the orchids exhibit several unique life history traits which allow them to occupy a peculiar niche in the terrestrial ecosystems. Microscopic seeds that subscribe to wind dispersal are their most prominent feature. The seeds which are dispersed into the new habitats either perish or adapt to the new environment. If they take the adaptation route, they experience alteration on the genetic echelon giving rise to phenotypic modification in the plant consecutively giving rise to new species, subspecies or varieties. Epiphytic orchids and other vascular epiphytic groups are well suited to be indicators of the health and biodiversity of the rainforest, not only because they are important source of nutrients for other flora and fauna, but also because they are very sensitive to shifts in microclimate and have slow growth (Benzing, 1981). A large number of orchids also exhibit a close association with the lower groups of plants especially mosses and liverworts. The present study aspires to comprehend the distribution of orchids in different altitudinal zones as well as different habitat types and life forms on a deeper level. No such detailed study has been undertaken so far in this region.

Date of publication: 30th December, 2012

Fig. 1. Map of Western Himalaya

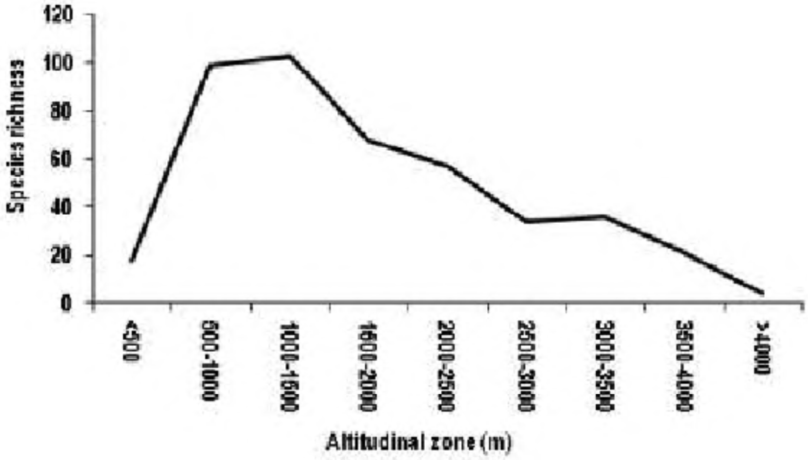

Fig. 2. Overall distribution patterns of orchid species in different altitudinal zones.

MATERIALS AND METHODS

Study area

The study was conducted in the Western Himalaya region of India between 28^0 45'- 36^0 20' N latitude and 73^0 26' - 80^0 24' E longitude. The study area comprises of three states *viz*., Uttarakhand (UK), Himachal Pradesh (HP) and Jammu & Kashmir (J&K) occupying approximately 3,31,402km² area, which is roughly 10.08 % of India's total geographic area. The altitude varies from 300m to 7800m (Fig. 1).

Data collection

Extensive field data were collected from 2005 to 2010 covering various eco-climatic zones of the study area. Secondary data were collected from various floras; Collett (1902), Duthie (1906), Blatter (1928), Raizada & al. (1981), Vij & al. (1982 & 1983), Chowdhery and Wadhwa (1984), Deva and Naithani (1986) and Pangtey & al. (1991). Data were also collected from various herbaria viz., Botanical Survey of India, Northern Circle (BSD), Forest Research Institute (DD), Wildlife Institute of India (WII), Kumaun University Nainital (NTL), H.N.B Garhwal University, Srinagar (GUH) and Punjab University Herbarium (PAN). During the field visits, various parameters such as habit, life form by using Raunkiaur's classification (Mueller-Dombois and Ellenberg, 1974), altitude, forest types and associated species were recorded for 222 species. A total of nine elevation zones were divided with 500m intervals between 300 and 4800m (the highest limit for the occurence of orchids in Western Himalaya is 4800m), from <500m to > 4000m. Based on the information on the altitudinal range of each orchid species available in published data, the presence of each species in every 500m interval was recorded. 18 habitat types were identified for orchids, based on species presence in each habitat (Table 1). Species richness here is defined as the total number of species present in a particular habitat and altitudinal zone.

Data analysis

Data were analyzed by using the software Bio Diversity Pro, 1997 and Excel 2007. The Jaccard index and the number of shared species between different habitats were calculated to assess similarities of species assemblages (Magurran, 2004). Jaccard index is computed as 1/[2B/(1+B)], where B is Bray - Curtis dissimilarity.

RESULTS AND DISCUSSION

Distribution patterns

The overall pattern of orchid species richness along altitudinal zone is shown in Fig. 2. There is a significant increasing trend in total species richness from 500m to 1500m. From 1500m to > 4000m there is a clear decrease, except for a slight plateau between 3000m to 3500m. Thus orchid species richness in the Western Himalaya is peaked at lower elevation zone from 1000 - 1500m. About 47% of the total species of orchids found in the study area are found in this zone. This falls within the general pattern of an initial increase in species richness with altitude, followed by a peak then a decline with further increasing altitude. It is similar to those pteridophytes found in Panama with maximum at 500-1500m (Lellinger, 1985), tree species in the Qilian mountain shows high diversity at 2400-2800m (Wang & al., 2003), bryophyte species richness in Nepal (Garu & al., 2007), fern species richness in Nepal with amaximum at 2000m (Bhattarai & al., 2004). According to Vettas and Gerytnes (2002), about half of the published studies showed a mid-elevation peak in plant species richness.

The distribution of species richness, along altitudinal gradient is governed by a series of interacting biological, climatic and historical factors (Colwell & Lees, 2000). Further, elevation represents a complex gradient along which many environmental variables change simultaneously (Austin & al., 1996). Thus, the effect of each variable could be difficult to separate and these interacting factors would be difficult to disentangle. The present study does not include any specific test on the mechanisms that resulted in the patterns of species richness; however factors that might affect this pattern were discussed.

Several hypotheses have been put forward to explain elevation patterns of species richness e.g. optimum humidity conditions at mid-elevations (Rahbek, 1995, 1997). The mid-elevation ranges with an optimal

Table 1 - Different habitat types and their characteristic features.

S.N.	Habitats	Altitudinal range	Remarks/ Characteristic species
1	Swamp (SW)	300-600	Found at the foot hills of the Himalayas in the Siwalik Hills
2	Sal forests (SF)	300-800	Almost pure forest of *Shorea robusta* spread in the Siwalik Hills and the Lower Himalaya.
3	Riverine forests (RF)	300-1200	Found along the river and streams. This habitat also includes evergreen and semi - evergreen forests. *(Albizia procera, Bombax ceiba, Toona ciliata, Alnus nepalensis, Engelhardtia spicata are the common species.)*
4	Chir-Pine forests (CPF)	1000-2000	Found in the entire study area except Kashmir. Dominated by *Pinus roxburghii*
5	Subtropical grassy slopes (GS)	800-1500	Open grassy slopes between forest in lower elevation
6	Oak-Pine forests (OP)	1500-1800	Chir - pine *(Pinus roxburghii)* forest generally mixed with *Quercus leucotrichophora* in its upper limit and forms a peculiar transition zone
7	Banj-oak forests (BOF)	1600-2300	*Quercus leucotrichophora,* mixed with other broad-leaved forest elements of higher altitude
8	Cupress forests (CF)	1800-2400	Very limited in the study area mainly dominated by *Cupressus torulosa*
9	Oak-mixed forests (OMF)	2200-2600	*Querces leucotrichophora* and *Q. floribunda*
10	Temperate grassy slopes (TGS)	1600-2700	Open grassy slopes between oak forests. *(Chrysopogon* spp.*)*
11	Moru-oak forests (MOF)	2200-2600	*Quercus floribunda*
12	Oak-Rhododendron forests (ORF)	2200-3000	*Rhododendron arboreum, Lyonia ovalifolia, Quercus leucotrichophora, Q. floribunda, Quercus semecarpifolia*
13	Kharsu-oak forests (KOF)	2700-3500	*Quercus semecarpifolia, Rhododendron arboreum Viburnum cotoni*
14	Temperate Conifer forests (TCF)	2400-3200	*Cedrus deodara, Abies pindrow, Abies spectabilis, Prunus cornuta*
15	Sub-Alpine Scrub (SAS)	2900-3600	Habitat appears just above the tree line. *(Rhododendron campanulatum, Betula alnoides, Sorbaria* spp.*)*
16	Danthonia Grassy slopes (DGS)	3600-4800	*Danthonia cachemyrioana*
17	Alpine marsh meadows (AMM)	3600-4500	Marshy meadows in alpine region
18	Herbaceous meadows (HM)	3500-4500	*Ranunculus* spp., *Primula* spp., *Potentilla* spp., *Polygonum* spp., *Sibaldia* etc.

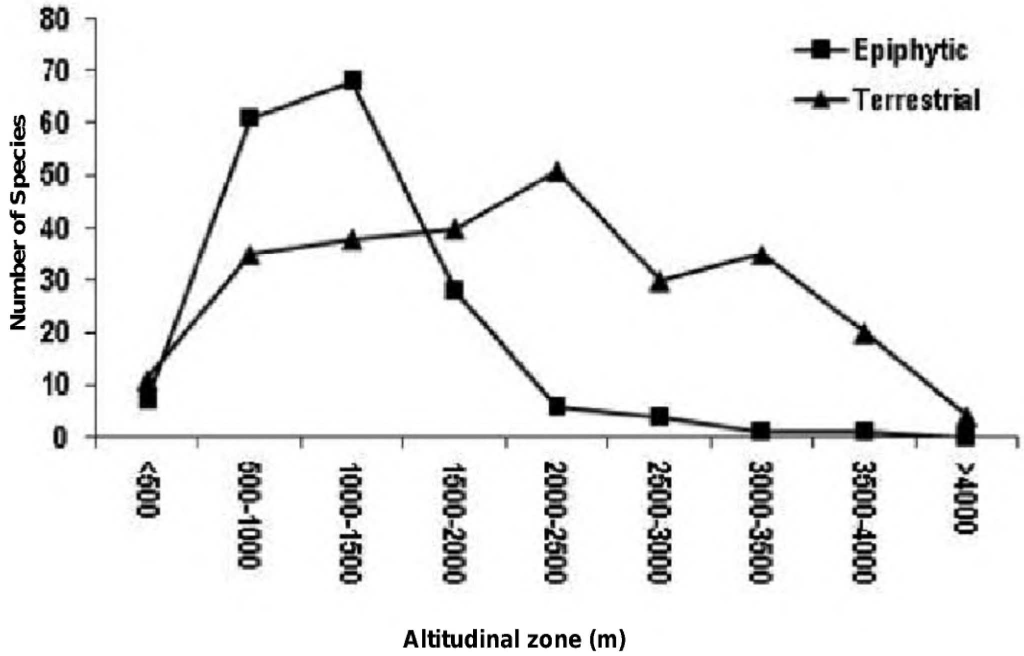

Fig. 3. Distribution patterns of epiphytic and terrestrial orchids in different altitudinal zones

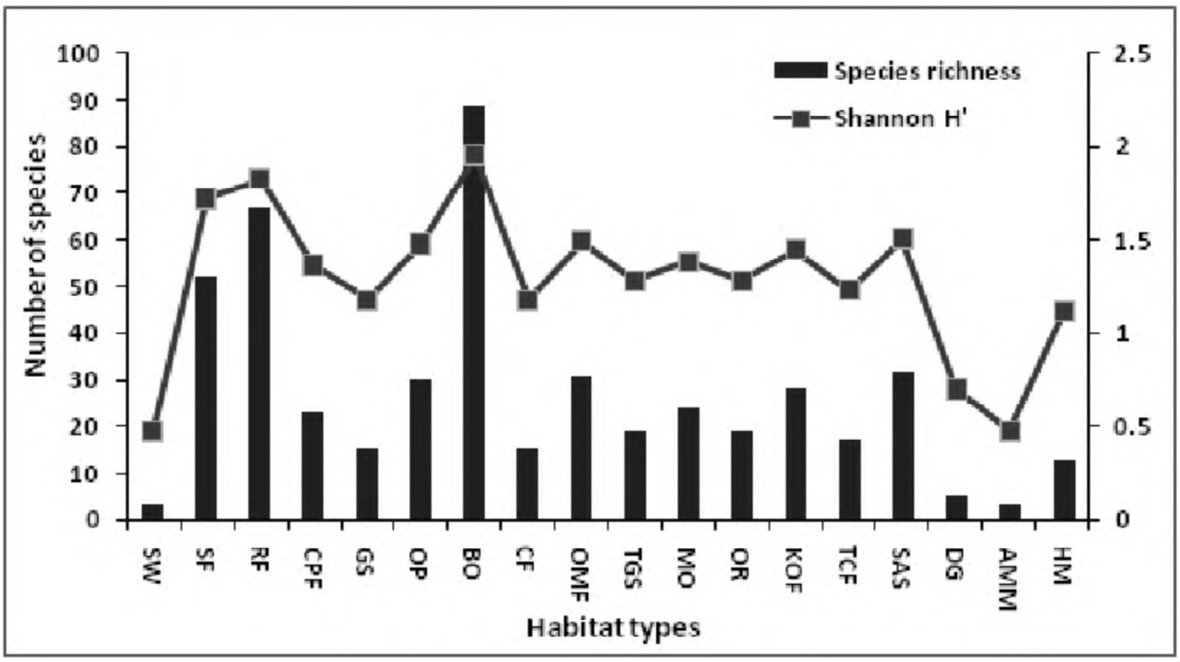

Fig. 4. Species richness in different habitats

Table 2 - Proportion of different life forms of orchids

S.N.	Life forms	No. species	%
1	Corm geophytes (Cg)	9	4
2	Epiphytic chamaephytes (Ech)	17	8
3	Fleshy leaved epiphyte (Fle)	9	4
4	Holomycotrophic coralloid geophytes (Hcg)	2	1
5	Holomycotrophic rhizome geophytes (Hrg)	7	3
6	Holomycotrophic tuberous rhizome geophytes (Htrg)	2	1
7	Pseudobulb epiphytes (Pe)	57	26
8	Pseudobulb geophytes (Pg)	22	10
9	Reduced stem epiphytes (Rse)	5	2
10	Rhizome geophytes (Rg)	27	12
11	Slender leaved epiphytes (Sle)	4	2
12	Tuberus geophytes (Tg)	61	27
	Total	**222**	**100**

Table 3 - Distribution of lifeforms in different habitat types.

Habitat	Life form (%)											
	Cg	Ech	Fle	Hcg	Hrg	Htrg	Pe	Pg	Rse	Rg	Sle	Tg
SW	0	0	0	0	0	0	0	2	0	3	0	0
SF	46	28	6	0	0	50	9	7	0	5	33	9
RF	8	33	44	0	8	0	28	7	57	3	44	2
CPF	0	0	0	0	8	0	6	2	0	2	0	8
GS	0	0	0	0	0	0	0	0	0	0	0	9
OP	0	14	13	0	0	0	13	4	0	2	0	4
BO	15	22	38	0	8	0	37	13	43	12	22	9
CF	0	0	0	0	0	0	1	5	0	3	0	5
OMF	0	0	0	0	38	50	1	14	0	9	0	6
TGS	0	0	0	0	0	0	0	2	0	0	0	12
MO	0	3	0	0	8	0	1	13	0	8	0	5
OR	8	0	0	0	0	0	0	11	0	9	0	4
KOF	8	0	0	50	31	0	2	11	0	8	0	5
TCF	0	0	0	0	0	0	0	11	0	11	0	2
SAS	15	0	0	50	0	0	3	0	0	21	0	7
DG	0	0	0	0	0	0	0	0	0	0	0	3
AMM	0	0	0	0	0	0	0	0	0	0	0	2
HM	0	0	0	0	0	0	0	0	0	6	0	5
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

combination of environmental resource were more preferable for many species to coexist (Lomolino, 2001; Brown, 2001). Therefore, more species of orchids were found in mid-elevation zone of Western Himalaya. In fact, the humid subtropical zone of the study area extends up to 1500m altitude. This zone receives much more rain fall (average annual rain fall between 150cm to 200cm) as compared to other higher altitudinal zones. Due to high moisture level, maximum numbers of epiphytic orchids are found in this zone. Above it the number of epiphytic orchids sharply decreases. (Fig. 3). The riverine pocket of this zone provides all the suitable condition for the growth and development of orchids. Within the study area, the eastern part, particularly the Kumaun region is mesic and only this part has more than 80% epiphytic orchids. Few epiphytic orchids are able to tolerate the entire spectrum of environment and their distribution is up to 4000m. For example, the member of genus *Pleione,* have the capacity to tolerate the environmental stress thus altering its nature of growth. They grow as terrestrials in the higher elevations and are deciduous in nature. In mid altitudinal zone, species that prefer warmth and the cool climate co-exist with each other. Major decline in epiphytic species richness was noticed above 1500m which could be due to the low moisture level.

Terrestrial orchids too have also shown a significantly increasing trend with respect to increasing altitude. The total species richness peaked at mid elevation zone from 2000 - 2500m. After that, the richness declines and again a small peak is formed at the zone at 3000-3500m (Fig. 3). Terrestrial species richness is very low at <500m and > 4000m. The low altitudinal zone receives less rainfall and temperature exceeds 45ºC at many places which are not favorable for the growth of orchids. In Himalayan regions, the pattern of different forest types and other communities often corresponds to elevation and topography. Variation in microclimate along with topography and elevation is a major factor for species distribution within a forest landscape.

Species richness in different habitats

The orchid species richness in different habitat types is shown in Fig. 4. Banj-oak forests (89) and Riverine forests (67) had the highest species richness followed by Sal forests (52). The lowest species richness was observed in Swamp habitat (3) and Alpine marsh meadows (3) followed by *Danthonia* grassy slopes (5). Shannon diversity index (H') also shows the highest diversity in Banj-oak forests (1.95) and in Riverine forests (1.83), while lowest diversity was found in Swamp habitat (0.48) and Alpine marsh meadows (0.48). Some of the most important and unique orchids found in Banj-oak forests are *Goodyera foliosa*, *Goodyera viridiflora*, *Goodyera biflora*, *Dendrobium monticola*, *Dendrobium denudans*, *Oberonia griffithiana*, *Phalaenopsis taenialis*, *Bulbophyllum hookeri*, *Bulbophyllum helenae* and *Calanthe plantaginea*. It has been understood that Riverine forest is one of the most suitable habitats for epiphytic orchids. Nevertheless, swamp habitat was found to have only two unique species while others contributed as follows :- Sal forests-4, Riverine forests-10, Subtropical grassy slopes-3, Cupresus forests-1, Moru-oak forests-3, Temperate grassy slopes-3, Oak-Rhododendron Forests-2, Sub-Alpine Scrub-2 and Alpine marsh meadows comprises of only one unique orchid species.

The results suggest that some species require specific habitats and every species has some limiting factors which govern their distribution. Species composition varies across the 18 different habitats. Three distinct groups of habitats were seen in cluster analysis which is based on Jaccard Similirty Index (Fig. 5). The highest similarity value (Sj= 74) was between habitat pairs Oak-Rhododendron-Moru-oak (OR-MO), which shared eleven orchid species.

In correspondence to the similarity analysis, no similarity values equal to one were observed, as a reflection of the fact that none of the habitat pairs were identical in terms of orchid species composition. Taking the index of similarity of Sj = 25 as a base line, the habitats are grouped into three major clusters while the fourth, Swampy habitat (SW) is not grouped with any habitats. These clusters can be recognized as subtropical (Sal forests to subtropical grassy slopes), temperate (Cupresus forests to temperate grassy slopes) and alpine (Sub-Alpine Scrub to Alpine marshy meadows).

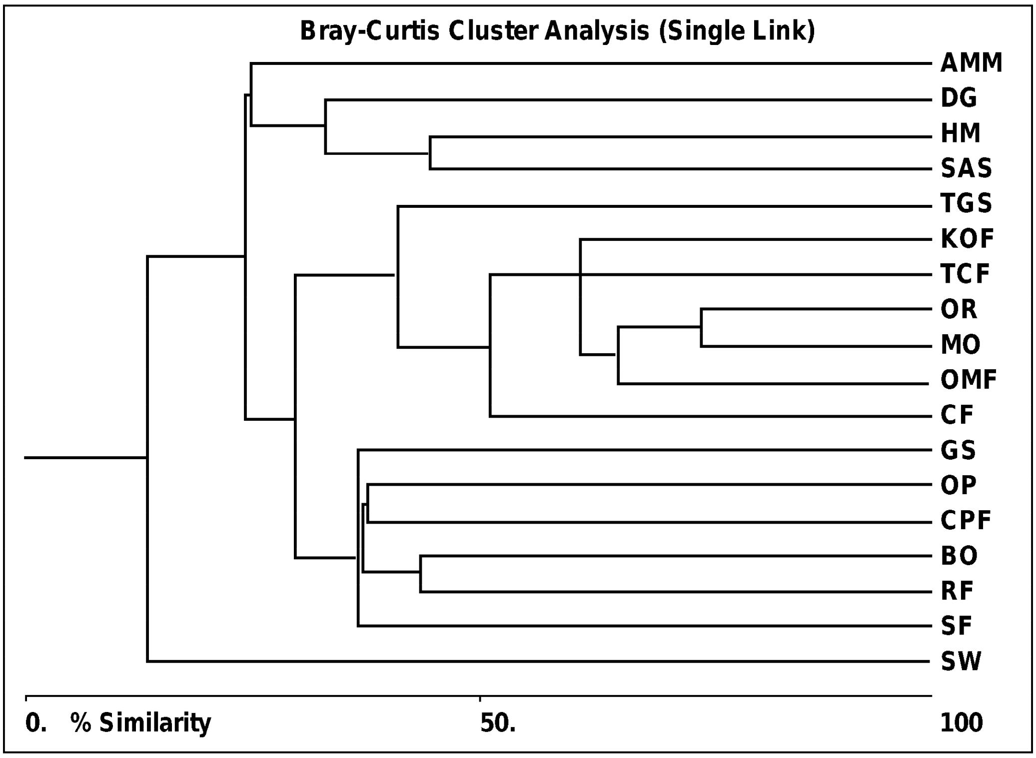

Fig. 5. Dendrogram of similarity between 18 habitats

Different Life forms of orchids

'Life form' refers to the functional aspect of a plant species. The distribution of plants in different habitats and altitude gives an idea of its ecological plasticity. The life form of plants subsumes species, which have similarities in the complex of ecological conditions characteristic of their habitats (Angelova & Tashev, 2005). The most abundant life-form was the tuberous geophytes with 61 species, representing about 27% of the total species (Table 2). This life form was common to all the 18 habitats except swamp habitat. The pseudobulb epiphytes (Pe) with 57 (26%) species was the second on the importance list followed in succession by the rhizome geophytes (Rg) represented by 27 (12%) species, the pseudobulb geophytes (Pg) with 10% and lastly the holomycotrophic coralloid geophytes (Hcg) represents only 1%. Table 3 shows the distribution of life forms with respect to habitat types.

Corm geophytes (cg) are distributed in six habitats. Most of the species (64%) prefer Sal forests (SF) followed by the Banj-oak forests (BO) and Subtropical grassy slopes (SGS) with 15% each. Epiphytic chamaephytes (Ech) are distributed in five habitats. The Riverine forests with 33% clearly take the lead over the Sal forests (28%), Banj-oak (22%),Oak-pine forests (14%). The moru-Oak forests represent the lowest (3%) with a single species *Gastrochilus distichus.* The maximum distribution of the Fleshy leaved epiphytes (Fle), dominated by the genus *Oberonia* (44 %) is seen in the riverine forest which is followed by the Banj-oak forests. Holomycotrophic coralloid geophytes (Hcg), represented by 1% and are distributed mainly in the temperate habitat of Kharsu-oak forests (KOF) and Sub-Alpine Scrub (SAS) habitat. Holomycotrophic rhizome geophytes (Hrg) occur in very dense forests where the ground is shielded from sunlight. They are distributed in five habitats with their maximum representation found to be in oak-mixed forests (38%) followed by Kharsu-oak forests (KOF).

Holomycotrophic tuberous rhizome geophytes (Htrg) are distributed only in two habitats. Pseudobulb epiphytes (Pe) are distributed in ten habitats but their maximum representation is found in Banj-oak forests (37%) followed by riverine forests (28%). Pseudobulb geophytes (Pg) are distributed in 13 different habitats; maximum representation is in oak-mixed forests (14%) followed by banj-oak and moru-oak with 13% each.

Reduced stem epiphytes (Rse) are distributed in only two habitats with a maximum representation in riverine forests (57%). Rhizome geophytes (Rg) are distributed in 14 different habitats with their maximum representation in Sub-Alpine Scrub (SAS) habitat and banj-oak habitat. Slender leaved epiphyes (Sle) are distributed in 3 habitats. Their maximum representation is in riverine forests (44%) followed by banj-oak forests (33%). Tuberous geophytes (Tg) are distributed in all the habitats except swamp habitat. Their maximum representation is in temperate grassy slopes habitat (12%) followed by subtropical grassy slopes and riverine forests 9% each. The overall complex analysis shows that the tuber geophytes (Tg) are mainly distributed in all the habitats which indicates their high ecological plasticity.

ACKNOWLEDGMENTS

The author is extremely thankful to Dr. Paramjit Singh, Director, Botanical Survey of India for providing facilities and encouragement. The Ministry of Environment and Forests, Government of India has been deeply acknowledged for their financial support of this study. Thanks to Dr. J.Jayanthi, BSI Western Regional centre, Pune for her necessary support and encouragement.

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