

FLORISTIC DIVERSITY OF BHADRA WILDLIFE SANCTUARY IN THE CENTRAL WESTERN GHATS REGION, KARNATAKA

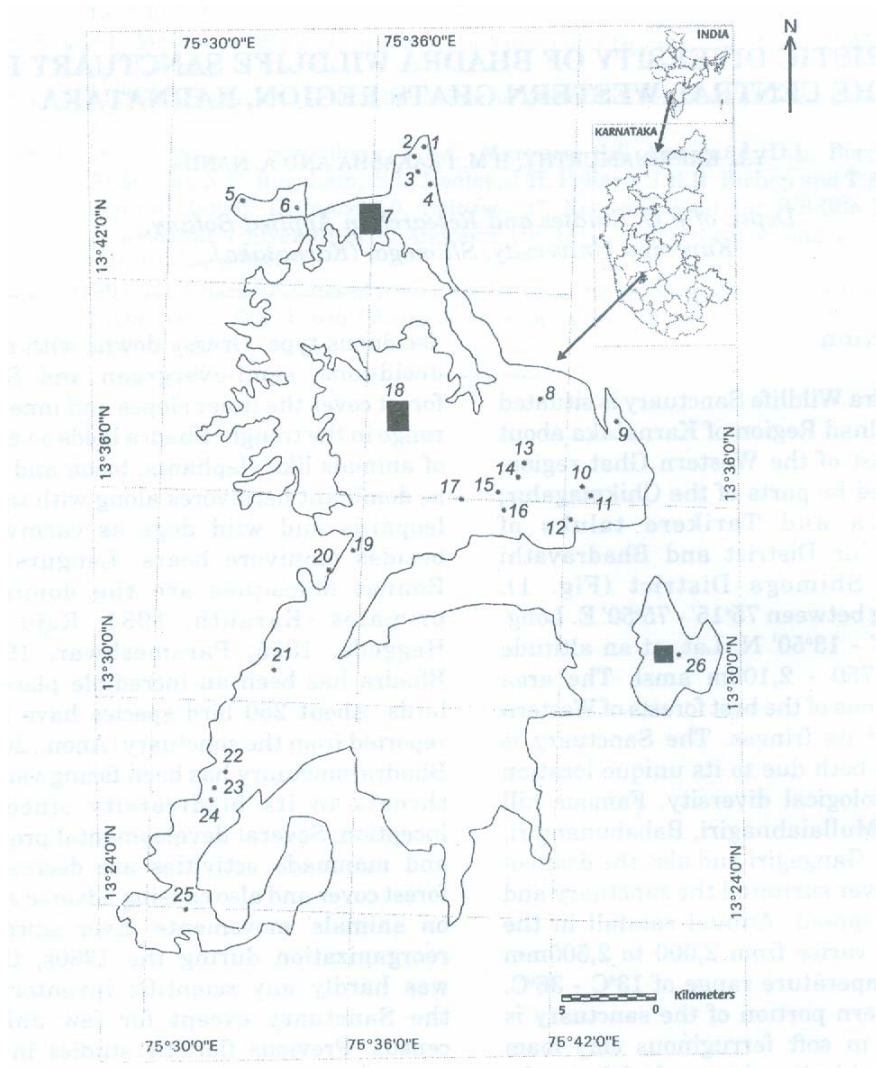
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Introduction

Bhadra Wildlife Sanctuary is situated in the Malnad Region of Karnataka about 50 km East of the Western Ghat region, surrounded by parts of the Chikmagalur, N.R. Pura and Tarikere taluks of Chikmagalur District and Bhadravathi taluk of Shimoga District (Fig. 1). Extending between 75°15' - 75°50' E. Long. and 13°25' - 13°50' N. Lat. at an altitude range of 750 - 2,100m amsl. The area comprises one of the best forests of Western Ghats and its fringes. The Sanctuary is important both due to its unique location and its biological diversity. Famous hill ranges of Mullaiahnagiri, Bababudangiri, Hebbegiri, Gangegiri and also the drain of Bhadra River surround the sanctuary and its water spread. Annual rainfall in the sanctuary varies from 2,000 to 2,500mm with a temperature range of 13°C - 36°C. The southern portion of the sanctuary is abundant in soft ferruginous clay loam soils while chlorite schist underlying rocks in the North-West region produces characteristic impervious clay soil. Higher elevations (Bababudan and other mountain ranges) are a rich tract of black cotton soil, with gravelly soil in some parts. The general pattern of vegetation broadly falls into four types : The forests of the valley floor, northern and eastern outer slopes are generally dry deciduous to moist

deciduous type. Grassy downs with moist deciduous, semi-evergreen and Shola forest cover the inner slopes and inner hill range in the trough. Bhadra holds a variety of animals like elephants, bison and deer as dominant herbivores along with tigers, leopards and wild dogs as carnivores besides omnivore bears. Langurs and Bonnet Macaques are the dominant primates (Karanth, 1981; Raju and Heggede, 1995; Parameshwar, 1996). Bhadra has been an incredible place for birds. About 250 bird species have been reported from the sanctuary (Anon., 2003). Bhadra sanctuary has been facing various threats to its biodiversity since its inception. Several developmental projects and manmade activities are decreasing forest cover and also causing adverse effect on animals' movements. Ever since its reorganization during the 1980s, there was hardly any scientific inventory in the Sanctuary except for few animal census. Previous floristic studies in the sanctuary were only random and much concentrated on preparing the database for the identification of the plants of the nearby areas (Yoganarasimhan *et al.*, 1990; Ramaswamy *et al.*, 2001). In view of this, the present study on floristic diversity of the sanctuary has been undertaken to fill this gap and to provide a comprehensive list of plants present in the sanctuary with various habitats.

Fig. 1

Location and map of Bhadra Wildlife Sanctuary showing the study areas

● Transects

■ Permanent plots

- | | | | |
|-----------------------|--------------------|-------------------|-------------------|
| 1. Hunasekatte | 2. Thamadihalli | 3. Gonibeedu | 4. Shankaraghatta |
| 5. Maridibba | 6. Aldara | 7. Choudikatte | 8. Kundur kaval |
| 9. Biranhalli | 10. Machan gudda | 11. Gordgal | 12. Kecige road |
| 13. Channaaiahna kere | 14. Lalbagh | 15. Lalbagh katri | 16. Sagavani kere |
| 17. Nerale road | 18. Sukhala hatti | 19. Nandigavi | 20. Hebbe |
| 21. Heggara | 22. Kodi | 23. Thegara gudda | 24. Shiragola |
| 25. Maduguni | 26. Kemmannu gundi | | |

Material and Methods

Based on preliminary observations of the different type of forests of Bhadra Wildlife Sanctuary, 30 study sites were chosen so as to cover the region in a relatively uniform manner during which adequate representation of the four major habitat types including dry deciduous hill type forests, moist deciduous forests, evergreen type of forests, Sholas and grassland type, were ensured (Fig. 1).

To prepare a database of plant species for the sanctuary phyto- sociological studies were conducted in each study site using transect of 250m x 4 m (Gentry, 1988). Each transect is further divided into five 50 m x 4 m quadrats. Plants above 10cm girth were considered as trees for enumeration. Shrubs and herbs were recorded in 4m x 4 m and 2 m x 2 m quadrats in the same 0.1 ha transect. The plants found along the marshy areas and plants that could not occur within the regular study area are randomly observed, recorded and included arbitrarily. All plants were identified in the field, except those whose voucher specimens were prepared and brought to the laboratory for identification. The identity of the species was confirmed by referring the *Flora of the Presidency of Madras* (Gamble and Fischer 1998), *Flora of Karnataka* (Saldanha, 1996), *Flora of Chikamagalur District* (Yoganarasimhan *et al.*, 1982) and *Flora of Shimoga District* (Ramaswamy *et al.*, 2001). The herbarium specimens are preserved in the herbarium of Department of Applied Botany, Kuvempu University, Shimoga (Karnataka). Transect data was summarized and abundance, density, and frequency for all the species has been calculated. Diversity indices such as Shanon and Simpson were calculated for

trees, herbs and climbers as in Magurran (1998).

Results and Discussion

In the present study a total of 406 species of flowering plants belonging to 294 genera and 98 families were enumerated which include 169 species of trees, 82 herbs, 70 climbers and 37 species of shrubs. The predominant families and their respective composition of genera and species are given in Table 1. Shanon diversity index of 3.9, 3.57, 3.4 and Simpson diversity index of 40.2, 26.14 and 16.84 calculated for herbs, climbers and trees category indicate that the sanctuary is rich in its floral composition. Among the genera, *Cassia* is represented by the higher number of species of 8 followed by *Ficus* with 6 species, *Ipomoea* and *Dioscorea* with 5 species each. About 56 species (14 %) of the enumerated flora were found to be endemic to Western Ghats (Shetty *et al.*, 2002) and 8 species were treated under the endangered 'Threat-I' category and 6

Table 1

*Predominant species composition in
Bhadra WLS*

Sl. No.	Family	Genera	Species
1	Fabaceae	24	47
2	Orchidaceae	21	25
3	Poaceae	17	21
4	Rubiaceae	13	17
5	Lauraceae	8	15
6	Euphorbiaceae	11	14
7	Asteraceae	12	12
8	Convolvulaceae	5	11
9	Acanthaceae	7	10
10	Apocynaceae	9	10

under 'near to threatened' category according to IUCN Red Data List (IUCN, 2000) (Table 2).

Bhadra WLS constitutes a variety of plant species along with different elevation gradients. Various biotic and edaphic factors have played dominant role in determining the forest growth in the sanctuary area. It harbours relatively higher diversity of valuable timber species like *Tectona grandis*, *Terminalia tomentosa*, *Santalum album*, *Dalbergia latifolia*, *Pterocarpus marsupium*, *Haldina cordifolia* etc. which are of common occurrence in the deciduous forest areas of Lakkavalli and Tanigebylu ranges while the shola forests in Kemmannugundi contain many economic species like *Myristica malabarica*, *Syzygium cumini*, *Cinnamomum malabattrum* etc. It is evident from the Table 3, that *Xylia*

xylorcarpa (614 individuals, D=20.47) was relatively denser species among trees in the sanctuary followed by *Terminalia paniculata* (526 individuals, D= 17.53) and *Wrightia tinctoria* (412 individuals, D=13.73). While *Ichnocarpus frutescens* (76 individuals, D=2.71) and *Stachytarpetia indica* (79 individuals, D=2.63) dominated the climber and herb category respectively (Tables 4 and 5). Sanctuary also comprises a rich composition of orchids. About 25 species of orchids have been enlisted, of which 19 were epiphytic (*Aerides ringens* C.Fisch, *Sarcanthus pausiflorus* Wt. Ic.t, *Pholidota pallida* Lindl. being abundant) and 6 were terrestrial species (*Habenaria heyneana* Lindl., *Malaxis rheedi* Rheed. S.W., *Satyrium nepalense* D.Don being abundant). Most orchids have occurred between elevations of 1,000 m to 1,200 m amsl. Further interesting 10 parasitic plant species were also observed in the

Table 2

Endangered Plant species of Bhadra WLS

Sl. No.	Species	Family	Life-form	Category*
1	<i>Costus speciosus</i> (Koenig) Sm.	Costaceae	Herb	Threat
2	<i>Garcinia indica</i> Chois.	Clusiaceae	Tree	Threat-I
3	<i>Gloriosa superba</i> L.	Liliaceae	Cli-Shrub	Threat-nt
4	<i>Hopea parviflora</i> Bedd.	Dipterocarpaceae	Tree	Threat-nt
5	<i>Hopea ponga</i> (Dennst.) Mabberly	Dipterocarpaceae	Tree	Threat-nt
6	<i>Impatiens acaulis</i> Arn.	Balsminaceae	Herb	Threat-I
7	<i>Litsea mysorensis</i> Gamble.	Lauraceae	Tree	Threat-I
8	<i>Nothopodytes foetida</i> (Wight)	Icacinaceae	Small tree	Threat?
9	<i>Rauwolfia serpentina</i> (L.) Benth. ex Kurz.	Apocynaceae	Herb	Threat-I
10	<i>Santalum album</i> L.	Santalaceae	Tree	Threat-I
11	<i>Schefflera rostrata</i> Wight.	Araliaceae	Tree	Threat-nt
12	<i>Zingiber cernuum</i> Dalzell.	Zingiberaceae	Herb	Threat-I

*Endangered plants (IUCN, 2000).

Table 3*Dominant Tree species of Bhadra WLS with their α -Diversity parameters*

Sl. No.	Species	Family	No. of Ind./30 Transects	Abundance/Transect	Density/Transect	Frequency/Quadrat
1	2	3	4	5	6	7
1	<i>Xylia xylocarpa</i> (Roxb.) Taub.	Mimosoidae	614	0.03	20.47	0.60
2	<i>Terminalia paniculata</i> Roth.	Combretaceae	526	27.00	17.53	0.93
3	<i>Wrightia tinctoria</i> R.Br.	Apocynaceae	412	0.03	13.73	0.43
4	<i>Tectona grandis</i> L.f.	Verbenaceae	383	0.05	12.77	0.63
5	<i>Catunaregam spinosa</i> (Thumb.) Tirveng	Rubiaceae	295	0.08	9.83	0.77
6	<i>Anogeissus latifolia</i> (Roxb. ex. DC.) Wall ex. Guill. & Perr	Combretaceae	258	0.09	8.60	0.73
7	<i>Lagerstroemia microcarpa</i> Wight.	Lythraceae	181	0.13	6.03	0.80
8	<i>Terminalia alata</i> Heyne ex. Roth.	Combretaceae	168	26.00	5.60	0.90
9	<i>Holarrhena pubescens</i> (Buch-Ham) Wall. ex. G. Don.	Apocynaceae	160	6.00	5.33	0.57
10	<i>Dalbergia latifolia</i> Roxb.	Faboidae	109	0.24	3.63	0.87
11	<i>Kydia calicina</i> (Roxb.)	Malvaceae	95	0.15	3.17	0.47
12	<i>Tabernaemontana alternifolia</i> (Roxb.) Nicols. & Suresh.	Apocynaceae	76	0.12	2.53	0.30
13	<i>Emblica officinalis</i> Gaertn.	Euphorbiaceae	71	0.20	2.37	0.47
14	<i>Grewia tilifolia</i> Vahl.	Tiliaceae	68	0.32	2.27	0.73
15	<i>Careya arborea</i> Roxb.	Lecythidaceae	64	0.27	2.13	0.57
16	<i>Cassia fistula</i> L.	Caesalpinoideae	64	0.27	2.13	0.57
17	<i>Pterocarpus marsupium</i> Roxb.	Faboidae	58	20.00	1.93	0.37
18	<i>Lagerstroemia parviflora</i>	Lythraceae	57	9.00	1.90	0.23
19	<i>Haldina cordifolia</i> (Roxb.) Ridsd.	Rubiaceae	55	5.00	1.83	0.70
20	<i>Diospyros melanoxylon</i> Roxb.	Ebenaceae	45	0.31	1.50	0.47
21	<i>Ziziphus rugosa</i>	Rhamnaceae	44	30.00	1.47	0.40
22	<i>Dillenia pentagyna</i> Roxb.	Dilleniaceae	41	0.32	1.37	0.43
23	<i>Ziziphus xylopyrus</i>	Rhamnaceae	41	0.22	1.37	0.30

Contd...

1	2	3	4	5	6	7
24	<i>Gnidia glauca</i> (Fresen.) Gilg.	Thymelaeaceae	36	0.31	1.20	0.37
25	<i>Radermachera xylocarpa</i>	Bignoniaceae	34	0.50	1.13	0.57
169-species		55-families				
		Sub total	3955	126.62	131.83	14.17
		Others Total	686	475.09	22.87	16.74
		Grand total	4641	601.7	154.7	30.63
Shannon Diversity Index				3.44		
Simpson diversity index (1/D)				16.84		

Table 4

Dominant Climbers and creepers of Bhadra WLS with their α -Diversity parameters

Sl. No.	Species	Family	No. of Ind./30 Transects	Abundance/Transect	Density/Transect	Frequency/Quadrat
1	2	3	4	5	6	7
1	<i>Ichnocarpus frutescens</i> (L.) R. Br.	Apocynaceae	76	2.71	2.53	0.93
2	<i>Hemidesmus indicus</i> (L.) R. Br.	Apocynaceae	68	2.52	2.27	0.90
3	<i>Cyclea peltata</i> (Lam.) J. Hooker and Thoms.	Menispermaceae	57	2.28	1.90	0.83
4	<i>Argyreia nervosa</i>	Convolvulaceae	52	2.89	1.73	0.60
5	<i>Dioscorea oppositaefolia</i> L.	Dioscoreaceae	41	2.28	1.37	0.60
6	<i>Asparagus racemossus</i> Willd.	Liliaceae	40	1.90	1.33	0.70
7	<i>Argyreia pilosa</i> Wt. & Arn	Convolvulaceae	31	2.07	1.03	0.50
8	<i>Clematis gouriana</i> Roxb. ex.DC.	Ranunculaceae	31	2.07	1.03	0.50
9	<i>Carissa carandas</i> L. Matt.	Apocynaceae	27	1.59	0.90	0.57
10	<i>Merremia tridentata</i> Hall.f.	Convolvulaceae	26	2.17	0.87	0.40
11	<i>Acacia concinna</i> (Willd.)	Mimosaceae	24	1.41	0.80	0.57
12	<i>Pothos scandens</i> L.	Araceae	23	2.88	0.77	0.27
13	<i>Aristolochia indica</i> L.	Aristolochiaceae	21	1.75	0.70	0.40
14	<i>Tragia hispida</i> Willd.	Euphorbiaceae	21	3.00	0.70	0.23

Contd...

1	2	3	4	5	6	7
15	<i>Cryptolepis buchnanii</i> Roem. & Schutt.	Asclepiadaceae	20	1.43	0.67	0.47
16	<i>Passiflora foetida</i> L.	Passifloraceae	19	1.46	0.63	0.43
17	<i>Atlantia wightii</i> Tanaka	Rutaceae	16	2.67	0.53	0.20
18	<i>Celastrus paniculata</i> Willd.	Celastraceae	16	1.33	0.53	0.40
19	<i>Ipomoea palmata</i> Forskal	Convolvulaceae	16	1.00	0.53	0.53
20	<i>Smilax zeylanica</i> L.	Smilacaceae	16	1.60	0.53	0.33
21	<i>Ipomea staphylina</i> R & S.	Convolvulaceae	15	1.36	0.50	0.37
22	<i>Diplocyclos palmatus</i> (L.) Jeffrey	Cucurbitaceae	14	1.17	0.47	0.40
23	<i>Toddalia asiatica</i> L. Lam	Rutaceae	12	2.40	0.40	0.17
24	<i>Aristolochia tagala</i> Cham.	Aristolochiaceae	11	1.38	0.37	0.27
25	<i>Jasminum malabaricum</i> Wt. Ic. t.	Oleaceae	11	1.00	0.37	0.37
66-Species		26-Family				
		Sub total	704	48.30	23.47	11.93
		Others total	145	43.10	4.83	4.50
		Grand total-	849	91.40	28.30	16.43
Shannon Diversity index				3.57		
Simpson diversity index (1/D)				26.14		

Note: Scan Clim= Scandent Climber, Cl-He= Climbing Herb, Cl-Sh= Climbing Shrub, Tw- He= Twining Herb

Table 5

Dominant Herbs of Bhadra WLS with their α -Diversity parameters

Sl. No.	Species	Family	No. of Ind./30 Transects	Abundance/ Transect	Density/ Transect	Frequency/ Quadrat
1	2	3	4	5	6	7
1	<i>Stachytarpetia indica</i> (L.) Vahl.	Verbenaceae	79	3.29	2.63	0.80
2	<i>Elephantopus scaber</i> L.	Asteraceae	64	2.91	2.13	0.73
3	<i>Barleria involucrata</i> (Dalzell)	Acanthaceae	57	2.59	1.90	0.73

Contd...

1	2	3	4	5	6	7
4	<i>Sida acuta</i> N.Burman.	Malvaceae	57	3.00	1.90	0.63
5	<i>Blepharis asperrima</i> Nees.	Acanthaceae	56	2.95	1.87	0.63
6	<i>Euphorbia heterophylla</i> L.	Euphorbiaceae	53	6.63	1.77	0.27
7	<i>Spilanthes acmella</i> DC.	Asteraceae	49	4.90	1.63	0.33
8	<i>Bidens pilosa</i> .L.	Asteraceae	43	4.78	1.43	0.30
9	<i>Centella asiatica</i> (L.) Urban	Apiaceae	41	5.13	1.37	0.27
10	<i>Ageratum conyzoides</i> L.	Asteraceae	38	3.17	1.27	0.40
11	<i>Cassia mimosoides</i> L.	Caesalpiaceae	38	6.33	1.27	0.20
12	<i>Crotalaria pallida</i> Aiton.	Papilionaceae	35	2.33	1.17	0.50
13	<i>Canscora diffusa</i> Lam.	Gentianaceae	34	2.83	1.13	0.40
14	<i>Triumfetta rhomboidea</i> N. Jaacq.	Tiliaceae	34	2.13	1.13	0.53
15	<i>Oxalis corniculata</i> L.	Oxalidaceae	33	2.54	1.10	0.43
16	<i>Tridax procumbens</i>	Asteraceae	29	3.22	0.97	0.30
17	<i>Andrographis glandulosa</i> Nees.	Acanthaceae	26	2.60	0.87	0.33
18	<i>Crassocephalum crepidioides</i> (Benth.) S. Moore.	Asteraceae	26	2.89	0.87	0.30
19	<i>Curculigo orchiodies</i> Gaertner.	Amaryllidaceae	26	2.17	0.87	0.40
20	<i>Curcuma neilgherrensis</i> Wt.	Zingiberaceae	25	1.56	0.83	0.53
21	<i>Hyptis suaveolens</i> Poit.	Lamiaceae	24	2.67	0.80	0.30
22	<i>Borreria stricta</i> K.Sch.	Rubiaceae	23	2.88	0.77	0.27
23	<i>Mimosa pudica</i> L.	Mimosaceae	23	2.09	0.77	0.37
24	<i>Synedrella nudiflora</i> (L.) Gaertn.	Asteraceae	23	4.60	0.77	0.17
25	<i>Desmodium pulchellum</i> (L.) Benth.	Papilionaceae	22	1.22	0.73	0.60
82-Species		40-Family				
Sub Total			958	81.39	31.93	10.73
Other total			403	78.48	13.43	8.63
Grand total			1361	159.87	45.36	19.36
Shannon Diversity index				3.90		
Simpson diversity index (1/D)				40.20		

sanctuary. The grassland on the high elevations of hill tract has got a number of palatable grasses to the herbivores. Species of *Themeda*, *Cymbopogon*, *Cynodon* and *Brachiaria* were the most frequently occurring grasses during the study. Sanctuary is a 'valley of bamboo' with the occurrence of enormous amount of bamboo brakes. Species of *Dendrocalamus*,

Bambusa, *Ochlandra* are distributed through out the sanctuary. *B. arundinacea* was seen along the periphery of backwaters of Bhadra Reservoir.

The endangered and endemic plants, identified through the study, may draw attention of the forest managers for the proper care and protection.

Acknowledgements

The authors are grateful to the Ministry of Environment and Forests, Government of India for the financial support vide project No.14/10/2001-ERS-RE, 2003. Thanks are also due to Karnataka Forest Department for permission to carry out the studies, Prof. R. Sukumar, Centre for Ecological Sciences, Indian Institute of Science, Bangalore for the helpful suggestions and to the Chairman, Department of Applied Botany, Kuvempu University for the facilities.

SUMMARY

An extensive survey of the angiospermic floristic diversity was carried out in Bhadra Wildlife Sanctuary, Karnataka. A total of 30 transect each measuring 250 m x 4 m (0.1 ha) were laid randomly at different geographic locations of the sanctuary and plants were enumerated. The enumeration, carried out in the transects resulted in a total of 406 species, 294 genera belonging to 98 families. Of these enumerated plant species, 169 were tree forms, 37 shrubs, 82 herbs, 70 climbers and remaining were miscellaneous category. *Xylia xylocarpa* form the denser species among the trees in the sanctuary with a total of 614 trees/ 30 transects (D= 20.47 trees/transect) while *Ichnocarpus frutescens* (76 individuals, D=2.53) and *Stachytarpetta indica* (79 individuals, D= 2.63) were dominant among climbers and herbs respectively. The study also recorded a very good Shannon -Wiener and Simpson diversity index of 3.4 and 16.84 for trees, 3.57, 26.14 for climbers and 3.9, 40.2 for herbs. Twelve species among these were designated under endangered threat category while 56 were remarked as endemic to Western Ghats and 106 species as rare. Over 234 plant species were commonly distributed in the sanctuary.

Key words : Bhadra Wildlife Sanctuary, Western Ghats, Karnataka, Flora, Diversity, Status, Endangered species.

मध्यवर्ती पश्चिमी घाट प्रदेश कर्नाटक के भद्रा वन्य प्राणि अभयारण्य की पादपीय विविधता

वाई०एल० कृष्णामूर्ति, एच०एम० प्रकाश व ए० नन्दा

सारांश

भद्रा वन्य प्राणि अभयारण्य, कर्नाटक के संवृतबीजा पेड़-पौधों की विविधता का विस्तृत सर्वेक्षण किया गया। अभयारण्य की विभिन्न भौगोलिक स्थलियों में यादृच्छतया 250 x 4 मी० (0.1 हेक्टे०) साथ वाले कुल 30 संक्षेत्र डाले गए। इन संक्षेत्रों में की गई गणना के परिणामस्वरूप यहां 98 कुलों की कुल 406 जातियां और 294 प्रजातियां मिली। गिने गए पेड़-पौधों में 169 जातियां वृक्षों की 37 क्षुपों की, 82 शाको की व 79 आरोहियों की थी तथा

बाकी बची जातियां फुटकर श्रेणी में आती हैं। इस अभयारण्य में वृक्षों में सबसे ज्यादा सघनता *जीलिया जायलोकार्पा* की है जिसके 30 संक्षेत्रों में (डी=20.47) 614 वृक्ष मिले जबकि आरोहियों और शाकों में क्रमशः *इक्नोकार्पस फ्रुटिसेस* (76 पादप, डी=2.53) और *स्टेकिटारपेटा इण्डिका* (79 पादप, डी=2.63) का बाहुल्य देखा गया। इस अध्ययन में बहुत अच्छे शैन्नो-वीनेर और सिम्पसन विविधता निर्देशांक भी आलेखित हुए जो वृक्षों के लिए 3.4 और 16.84, आरोहियों के लिए 3.57 और 26.14 शाकों के लिए 3.9 और 40.2 रहते पाए गए। इनमें से बारह जातियों को संकटापन्न श्रेणी में रखा गया जबकि 56 को पश्चिमी घाट प्रदेश में ही स्थान सीमित रहती श्रेणी तथा 106 जातियों को दुर्लभ श्रेणी में रखा गया है। 234 से अधिक पादप जातियां पूरे अभयारण्य में आम ढंग से वितरित हुई मिली है।

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