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Studies on phytodiversity at narhar conservation forest region of Chirawa, Rajasthan during winter season

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Abstract
Phytodiversity helps our lives in various means. In recent decade, due to increasing human activities, plant diversity is decreasing which is at alarming rate. To protect, phytodiversity, various conservation reserves have been declared. In the rpesent investigation, a survey of phytodiversity was conducted at Narhad conservation forest region of Chirawa, Jhunjhnu, Rajasthan during October to January 2022-23. During survey, a total of 83 plants were identified which included 1 climber, 28 herb, 25 shrub, 25 tree and 5 undershrub. The identified plants were belonged to 37 different families. The highest number of plants belonged to Fabaceae family. Frequency, density, abundance and IVI were also calculated for each species. The current study is a reminder to conserve the pivotal resources bestowed upon us by mother nature in the form of plants. Considering the current state of affairs, if the biodiversity extinction continues to occur at this rate, the day is not far off when all forms of life will cease to exist on earth. In this context, setting up of conservation reserves like Narhad conservation forest region by state and central governments is a crucial step towards amelioration of the pathetic situation.

Keywords: Phytodiversity, narhad conservation forest area, etc

Introduction

Humans may refer to themselves as the most advanced species presently existing on earth, but it is none other than the plants, that have been bestowed with the attribute to occupy the central stage in this so called harmonious ecosystem, which sustains the cascade of events that enable perpetuation of life on earth. Plants fulfill tremendous roles in this interwoven series of events- by acting as primary producers by providing food and nutrition, supplying oxygen and also acting as a reservoir of phytochemicals exhibiting potent antimicrobial activity against disease causing pathogens **(**Quijas *et al.*, 2010; Lavore, 2013**)** [18, 13]. However, increasing globalization and urbanization in the last few decades owing to increased anthropogenic activities has led to an abrupt decline in the plant biodiversity. Government agencies and common people have tried to ameliorate this pathetic situation by adoption of a number of practices and implementation of reformative measures to conserve plant biodiversity (Rawat *et al.*, 2015; Rathee *et al.*, 2022; Pathak *et al.*, 2013**)** [21, 19, 16]. In this context, the current study is an attempt to study the plant biodiversity of Narhar conservation forest region, located in Chirawa in Jhunjhunu district of Rajasthan over a period of October-January (winter season) during the year 2022-23. The study showcases the immense plant biodiversity of the region comprising of several herbs, shrubs, trees, undershrubs and climbers belonging to several plant families. Furthermore, the study shows results pertaining to relative abundance as well as richness of plant biodiversity in this area using several parameters such as Frequency, density, abundance, relative frequency, relative density, relative abundance and importance value index. Furthermore, the results of the study showcase categorization of the plant species based on their family as well as habitat. The results of the study provide crucial insights into the population density and species richness of several plant species by highlighting the decline in relative numbers of economically as well medicinally important plants. Furthermore, the study prompts the audience as well as scientific community to find out the root cause behind dwindling plant biodiversity and undertake corrective measures to reform this anarchical situation.

Materials methods

The study area

Rajasthan, situated at the north-western part of India is the biggest state in the country of India and lies between 23°30' and 30°11' North latitude and 69°29' and 78°17' East longitude. The huge portion of the state of Rajasthan is desiccated and houses the biggest Indian desert- the Thar Desert known as the 'Maru-kantar'. The oldest chain of fold mountains- the Aravalli Range splits the state into two geographical zones- desert at one side and forest belt on the other.

Jhunjhunu district is located in North-Eastern part of Rajasthan state with its geographical extensions in between 24º38' to 28º31' N latitudes and 75º02' to 76º06' E longitudes. It is a part of the sub arid region of Thar desert and the climate of Jhunjhunu district is mainly dry. The summer months are hot while the winter months are cool (Anonymous, 2008). Jhunjhunu district includes six tehsils namely Buhana, Chirawa, Khetri, Jhunjhunu, Nawalgarh and Udaipurwati in which Buhana tehsil emerged out as a new tehsil on the map of Jhunjhunu district.

Chirawa is a town in Chirawa Tehsil in Jhunjhunu District of Rajasthan State, India. It belongs to Jaipur Division. It is located 32 km towards East from district headquarters Jhunjhunu. It is a Tehsil head quarter. The geographical location of Chirawa is in between the road connecting Pilani and Jhunjhunu towns. On geographical scale the town is situated in the Northern plains of India with small touch of the great Thar desert and covers 497.8 km^2 of geographical area. Geographically area is the mixture of sandy dunes, hillytract, foothills areas and most fertile plain areas

adjoining to Katli river. Ecological situation of the study area ranges from semi-arid to arid regions.

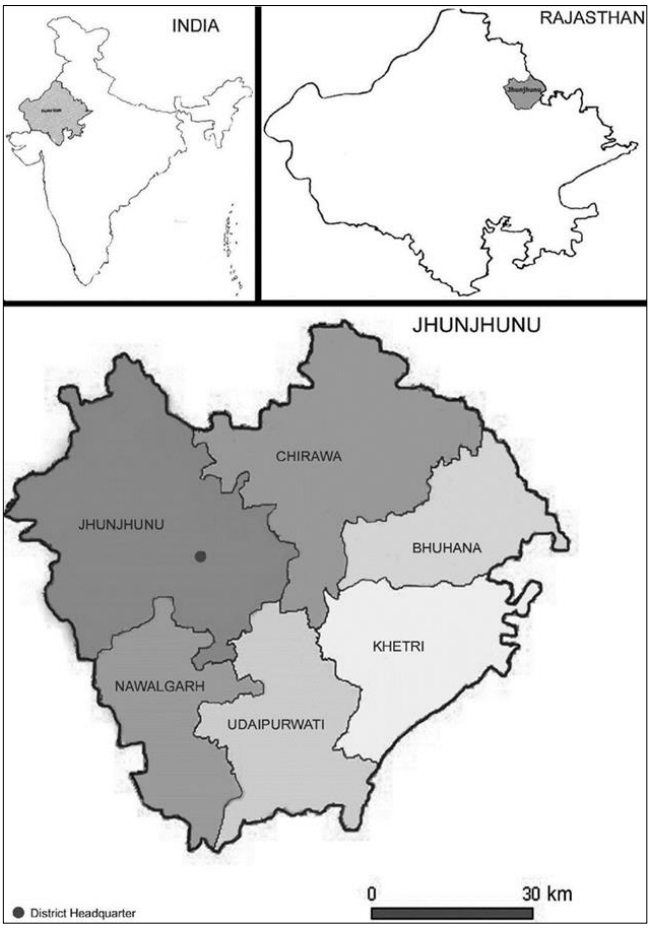

Fig 1: Map showing the study area

The present study was conducted at Narhar conservation forest region of Chirawa tehsil. It is declared as a conservation forest area by Rajasthan government in 17 June, 1985. It covers about 0.83 km^2 area of the Chirawa tehsil. It is located 31 km towards east from district head quarters Jhunjhunu, 9 km from Chirawa and 180 km from state capital Jaipur. Kherla (6 km), Shyopura (6 km), Shyam Vatika (6 km), Bass Gaon (6 km), Khudania (6 km) are the nearby villages to Narhar.

Fig 2: Details of Narhar Conservation forest area

Survey of Phytodiversity

Survey was conducted at Narhar conservation forest region during October-January, 2022-23. Plant collection was done to identify the taxonomical properties of plants. So, intensive exploration trips were also conducted to document plants and to know prevailing biodiversity of the selected area. The portion of specimen were collected in clear phyllotaxy and branching system, kept in plastic bags. Plant species were identified with the help of Flora of India (Sharma and Bala Krishnan, 1996), Monograph (Bhandari, 1990) and also by local inhabitants like Vaidas, homeopath, villagers, folk, Hakim etc., by interviews and questionnaires in the study area.

Analysis of data

Frequency, density, abundance, relative frequency, relative density, relative abundance were calculated by using their respective formulae.

Frequency

It is the number of the sampling units (as%) in which a particular species occurs, by taking any sampling unit like quadrate, transect and point.

$$\text{Frequency (\%)} = \frac{\text{No. of sampling units in which the species occurred}}{\text{Total no. of sampling units studied}} \text{ X } 100$$

Relative frequency

Relative frequency = frequency of an individual species/ total frequencies of all species

Density

Density represents numerical strength of a species in the community. The number of the species in any unit area is called its density.

$$\text{Density} = \frac{\text{Total no. of individuals of the species in all the sampling units}}{\text{Total no. of sampling units studied}} \text{ X } 100$$

Relative Density

Relative density = density of individual species/ total densities of all species.

Abundance

This is the no. of any species per sampling unit of occurrence,

$$\text{Abundance} = \frac{\text{Total no. of individuals of the species in all the sampling units}}{\text{No. of sampling units in which the species occurred.}} \text{ X } 100$$

Important value index

In general, the importance value index (IVI) measures how dominant a species is in a given forest area. The importance value index (IVI) of tree species was determined as the sum of relative frequency, relative density, and relative abundance.

Results

Abundance and distribution of plants in Narhar conservation forest region

The results in Table 1 show Phytodiversity of Narhar conservation forest region over a period of October-January (winter season) during the year 2022-23. The relative abundance as well as richness of plant biodiversity in this area has been expressed in terms of various parameters such as Frequency, density, abundance, relative frequency, relative density, relative abundance calculated using their respective formulae decribed in the methodology section.

The results in Table 1 show varying frequency of different plant species existing in the Narhar conservation area, with the highest frequency of 30 observed in case of 15 plants, including *Abutilion indicum, Aerva persica, Albizzia lebbeck, Anegalis arvensis, Argemone maxicana, Caesalpinia pulcherrima (L.), Jatropha curcas L., Nerium oleander L., Ocimum tenuiflorum L., Orobanche ramosa L., Phyla nodiflore,Physalis angulata L., Vachellia farnesiana (L.), Zizyphus mauritiana* and *Zizyphus nummularia.*

However, medium frequency range of 20 was observed in case of 28 plants, including *Achyranthes aspera, Aegle marmelos (L.) Corrêa, Aerva tomentera, Alternanthera tenella, Artemisia scoparia, Baugainvillia, Bauhinia purpurea L., Batanites aegyptiaca, Calotropis procera, Citrus aurantiifolia, Dalbergia sisso, Datura metel, Ehretia acuminata R.Br., Eucalyptus camaldulensis, Euphorbia hirta, Lawsonia inermis L., Leucas aspera, Lyium herbarium, Malvastrum coromandelanum, Parthenium hysteropherus, Phyllanthus amarus, Schumach. & Thonn., Phyllanthus emblica L., Rhodocactus grandifolius, Ricinus communis, Saccharum munja, Saccharum spontaneum, Tagetes minuta L.* and *Withania somnifera.*

Plants belonging to low frequency range (10) were 41 in number, including *Azadirachta indica A.Juss., Capparis decidua, Carica papaya L., Catharanthus roseus, Cenchrus ciliaris L., Chenopodium album, Chenopodium murale, Clerodendrum phlomides, Cordia dichotoma, Croton spariflorus, Cyperus rotundus L, Datura innoxia, Desmostachya bipinnata,Digera muricata, Echinops echinatus, Ficus benghalensis L., Ficus religiosa L.,Fumaria indica, Gamochaeta pensylvanica, Heliotropium strigosum, Heliotropium europaeum, Indigofera linnaei, leptadenia pyrotechnica, Maytenus emarginata, Medicago polymorpha, Moringa oleifera Lam., Pedalium murex, Pithecellobium dulce (Roxb.), Pongamia pinnata, Prosopis cineraria, Prosopis juliflora, Rumex spinosus, Salvadora oleoides, Salvadora persica, Sonchus oleraceus, Senna hirsuta (L.), Senna siamea (Lam.), Sisymbrium irion,Tamarindus indica, L. Tecomella undulata* and *Verbesina enceliodes.* The relative frequency of plants with frequency range of 30, 20 and 10 was found to be 0.01875, 0.0125 and 0.00625 respectively.

The plants were also classified based on their density and relative density, wherein, the density values of the plants ranged from 0.1 to 0.5 whereas the relative density values of the plants ranged from 0.00532 (for 0.1 density) to 0.02660 (for 0.5 density). The highest plant density and relative density was seen in case of *Orobanche ramosa L., Withania somnifera, Zizyphus mauritiana (*0.5 each) and *Abutilion indicum,Nerium oleander L., Phyla nodiflore, Ricinus communis and Vachellia farnesiana* (L.) (0.4 each).

Furthermore, the abundance and relative abundance of the plants was calculated on basis of their frequency and density, with the values of abundance ranging from 0.4 to 1 and relative abundance from 0.004464286 to 0.011160714. Most of the plants had an abundance value of 1 except a few which had lower values of abundance, including *Abutilion indicum,Nerium oleander L., Phyla nodiflore, Vachellia*

farnesiana (L.), Eucalyptus camaldulensis, Euphorbia hirta, Leucas aspera, Lyium herbarium, Malvastrum coromandelanum, Parthenium hysteropherus, Saccharum munja, Orobanche ramosa L., Zizyphus mauritiana, Pithecellobium dulce (Roxb.), Ricinus communis, Sonchus oleraceus, Sisymbrium irion, Tamarindus indica and *L. Withania somnifera.*

Furthermore, the results indicate varying dominance of different species in the area in terms of importance value index (IVI), computed on the basis of relative frequency, relative density and relative abundance. The results show that IVI values of plants ranged from 0.022468655 to 0.052042173, with the highest IVI value in case of *Orobanche ramosa L.* and *Zizyphus mauritiana.*

As per the values of IVI, following inferences can be drawn:

- Nearly 2.38% plants had IVI value of 0.052.
- Nearly 4.76% plants had IVI value of 0.048
- Nearly 1.19% plants had IVI value of 0.043.
- Nearly 1.19% plants had IVI value of 0.039.
- Nearly 8.33% plants had IVI value of 0.036.
- Nearly 22.62% plants had IVI value of 0.034.
- Nearly 44.05% plants had IVI value of 0.023.
- Nearly 4.76% plants had IVI value of 0.022.

Table 1: Details of phytodiversity observed in the study area during survey

S. No.	Name of plant	Common name	Family	Habit	F (%)	D	A	IVI
1	*Abutilion indicum*	Kanghi	Malvaceae	S	30	0.4	0.75	0.048
2	*Achyranthes aspera*	Laljira	Amaranthaceae	H	20	0.2	1	0.034
3	*Aegel marmelos (L.) Corrêa*	Bel	Rutaceae	T	20	0.2	1	0.034
4	*Aerva persica*	Bui	Amaranthaceae	US	30	0.3	1	0.046
5	*Aerva tomentosa*	Bui	Amaranthaceae	US	20	0.2	1	0.034
6	*Albizzia lebbeck*	siris	Mimosaceae	T	30	0.3	1	0.046
7	*Alternanthera tenella*	Kalico Plant	Amaranthaceae	H	20	0.2	1	0.034
8	*Anagalis arvensis*	Neel	Primulaceae	S	30	0.3	1	0.046
9	*Argemone maxicana*	Satyanashi	Pappaveraceae	S	30	0.3	1	0.046
10	*Artemisia scoparia*	Bana	Asteraceae	H	20	0.2	1	0.034
11	*Azadirachta indica A.Juss.*	Neem	Meliaceae	T	10	0.1	1	0.023
12	*Baugainvillia*	Baugaib bel	Nyctaginaceae	C	20	0.2	1	0.034
13	*Bauhinia purpurea L.*	Orchid tree	Fabaceae	T	20	0.2	1	0.034
14	*Balanites aegyptiaca*	Desert date	Zygophyllaceae	S	20	0.2	1	0.034
15	*Caesalpinia pulcherrima (L.)*	peacock flower	Fabaceae	S	30	0.3	1	0.046
16	*Calotropis procera*	Aak	Asclepiddaceae	S	20	0.2	1	0.034
17	*Capparis decidua*	Ker	Capparidaceae	S	10	0.1	1	0.023
18	*Carica papaya L.*	Papaya	Caricaceae	T	10	0.1	1	0.023
19	*Catharanthus roseus*	Sadabahar	Aocyanaceae	T	10	0.1	1	0.023
20	*Cenchrus ciliaris L.*	Buffel grass	Poaceae	H	10	0.1	1	0.023
21	*Chenopodium album*	chilwa	amaranthaceae	H	10	0.1	1	0.023
22	*Chenopodium murale*	Khartua	Chenopodiaceae	H	10	0.1	1	0.023
23	*Citrus aurantiifolia*	Limau	Rutaceae	T	20	0.2	1	0.034
24	*clerodemdrum phlomides*	Bagflower	Lamiaceae.	S	10	0.1	1	0.023
25	*Cordia dichotoma*	Lehsuwa	Boraginaceae	T	10	0.1	1	0.023
26	*Croton spariflorus*	croton	Euphorbiaceae	US	10	0.1	1	0.023
27	*Cyperus rotundus L*	nutgrass	Cyperaceae	H	10	0.1	1	0.023
28	*Dalbergia sisso*	Indian rosewood	Fabaceae	T	20	0.2	1	0.034
29	*Datura innoxia*	Dhatura	solanaceae	S	10	0.1	1	0.023
30	*Datura metel*	Kala Dhature	solanaceae	S	20	0.2	1	0.034
31	*Desmostachya bipinnata*	Dab	Poaceae	H	10	0.1	1	0.023
32	*Digera muricata*	Ghundro	amaranthaceae	H	10	0.1	1	0.023
33	*Echinops echinatus*	Oont kateli	Asteraceae	H	10	0.1	1	0.023
34	*Ehretia acuminata R.Br.*	koda	Boraginaceae	T	20	0.2	1	0.034
35	*Eucalyptus camaldulensis*	Red Gum	Myrtaceae	T	20	0.3	0.666666667	0.036
36	*Euphorbia hirta*	Dudhi	Euphorbiaceae	H	20	0.3	0.666666667	0.036
37	*Ficus benghalensis L.*	Banyan Tree	Moraceae	T	10	0.1	1	0.023
38	*Ficus religiosa L.*	Pipal Tree	Moraceae	T	10	0.1	1	0.023
39	*Fumaria indica*	Gajar ghas	Papaveraceae	H	10	0.1	1	0.023
40	*Gamochaeta pensylvanica*	Cudweed	Asteraceae	T	10	0.1	1	0.023
41	*Heliotropium strigosum*	Chitti ka fool	Boraginaceae	H	10	0.1	1	0.023
42	*Heliotropium europaeum*	caterpillar weed	Boraginaceae	H	10	0.1	1	0.023
43	*Indigofera linnaei*	Bekharia	Fabaceae	H	10	0.1	1	0.023
44	*Jatropha curcas L.*	Physic Nut	Euphorbiaceae	S	30	0.3	1	0.046
45	*Lawsonia inermis L.*	Henna Tree	Lythraceae	S	20	0.2	1	0.034
46	*Leptademia pyrotechnica*	Kheep	Asclepiadeceae	S	10	0.1	1	0.023
47	*Leucas aspera*	dargal	Lamiaceae	H	20	0.3	0.666666667	0.036
48	*Lycium barbarium*	Mural	Solanaceae	H	20	0.3	0.666666667	0.036
49	*Malvastrum coromandelanum*	Jangli khariti	Malvaceae	US	20	0.3	0.666666667	0.036
50	*Maytenus emarginata*	Kankera	Celasteraceae	S	10	0.1	1	0.023
51	*Medicago polymorpha*	bur clover	Fabaceae	T	10	0.1	1	0.023

52	*Moringa oleifera Lam.*	drumstick tree	Moringaceae	T	10	0.1	1	0.023
53	*Nerium oleander L.*	Kaner	Apocynaceae	T	30	0.4	0.75	0.048
54	*Ocimum tenuiflorum L.*	Tulsi	Lamiaceae	S	30	0.3	1	0.046
55	*Orobanche ramosa L.*	Broomrapes	Orobanchaceae	H	30	0.5	0.6	0.052
56	*Parthenium hysteropherus*	Gajar Ghas	Asteraceae	H	20	0.3	0.666666667	0.036
57	*Pedalium murex*	bada Gokhru	Pedaliaceae	H	10	0.1	1	0.023
58	*Phyla nodiflora*	CAPEWEED	Verbenaceae	H	30	0.4	0.75	0.048
59	*Phyllanthus amarus Schumach. & Thonn.*	Bhuiavla	Phyllanthaceae	H	20	0.2	1	0.034
60	*Phyllanthus emblica L.*	Amla	Phyllanthaceae	S	20	0.2	1	0.034
61	*Physalis angulata L.*	balloon cherry	Solanaceae	H	30	0.3	1	0.046
62	*Pithecellobium dulce (Roxb.)*	*Jagli Jalebi*	Fabaceae	T	10	0.2	0.5	0.022
63	*Pongamia pinnata*	karanj	Fabaceae	T	10	0.1	1	0.023
64	*Prosopis cineraria*	Khejri	Fabaceae	T	10	0.1	1	0.023
65	*Prosopis juliflora*	Vilayati babool	Fabaceae	T	10	0.1	1	0.023
66	*Rhodocactus grandifolius*	Rose Cactus	Cactaceae	S	20	0.2	1	0.034
67	*Ricinus communis*	Arand	Euphorbiaceae	S	20	0.4	0.5	0.039
68	*Rumex spinosus*	Spiny dock	Polygonaceae	S	10	0.1	1	0.023
69	*Saccharum munja*	Kuncha	Poaceae	H	20	0.3	0.666666667	0.036
70	*Saccharum spontaneum*	Kaans	Poaceae	H	20	0.2	1	0.034
71	*Salvadora oleoides*	Jaal	Salvadoraceae	T	10	0.1	1	0.023
72	*Salvadora persica*	tooth brush	Salvadoraceae	T	10	0.1	1	0.023
73	*Sonchus oleraceus*	Gangli	Asteraceae	H	10	0.2	0.5	0.022
74	*Senna hirsuta (L.)*	woolly senna	Fabaceae	S	10	0.1	1	0.023
75	*Senna siamea (Lam.)*	Jahor	Fabaceae	S	10	0.1	1	0.023
76	*Sisymbrium irion*	Rocket mustard	Brassicaceae	H	10	0.2	0.5	0.022
77	*Tagetes minuta L.*	chinchilla	Asteraceae	H	20	0.2	1	0.034
78	*Tamarindus indica L.*	Tamarind	Fabaceae	T	10	0.2	0.5	0.022
79	*Tecomella undulata*	Rohida	Bignoiaceae	T	10	0.1	1	0.023
80	*Vachellia farnesiana (L.)*	needle bush	Fabaceae	S	30	0.4	0.75	0.048
81	*Verbesina enceliodes*	Jangli Surajmukhi	Asteraceae	S	10	0.1	1	0.023
82	*Withania somnifera*	Ashwgandha	Solanaceae	US	20	0.5	0.4	0.044
83	*Zizyphus mauritiana*	Ber	Rhamnaceae	S	30	0.5	0.6	0.052
84	*Zizyphus nummularia*	Jhadi ber	Rhamnaceae	S	30	0.3	1	0.046

Family-wise abundance and distribution of plants in Narhar conservation forest region

The results in Table 2 as well as the corresponding pie chart show Family-wise abundance and distribution of plants in Narhar conservation forest region region over a period of October-January (winter season) during the year 2022-23. As per the results shown, folllowing inferences can be drawn

- The highest number of plants belonged to Fabaceae (14).
- This was followed by Amaranthaceae and Asteraceae, each containing 7 plants.
- A total of 6 plants belonged to the family Solanaceae.
- Boraginaceae, Euphorbiaceae and Poaceae, each contained 4 plants followed by Lamiaceae containing 3 plants.
- Each of the families, namely, Apocyanaceae, Asclepiadeceae, Malvaceae, Moraceae, Papaveraceae and Phyllanthaceae contained 2 plants.
- Each of the families, namely, Bignoiaceae, Brassicaceae, Cactaceae, Capparidaceae, Caricaceae, Celasteraceae, Chenopodiaceae, Cyperaceae, Lythraceae, Meliaceae, Mimosaceae, Moringaceae, Myrtaceae, Nyctaginaceae, Orobanchaceae, Pedaliaceae, Polygonaceae, Primulaceae, Rhamnaceae, Rutaceae, Salvadoraceae, Verbenaceae and Zygophyllaceae contained just 1 plant.

Table 2: Family-wise distribution of the plants in the study area

Serial No.	Name of family	Number of plants	% Distribution
1	Amaranthaceae	7	8.3333
2	Aocyanaceae	2	2.3810
3	Asclepiadeceae	2	2.3810
4	Asteraceae	7	8.3333
5	Bignoniaceae	1	1.1905
6	Boraginaceae	4	4.7619
7	Brassicaceae	1	1.1905
8	Cactaceae	1	1.1905
9	Capparidaceae	1	1.1905
10	Caricaceae	1	1.1905
11	Celasteraceae	1	1.1905
12	Chenopodiaceae	1	1.1905
13	Cyperaceae	1	1.1905

14	Euphorbiaceae	4	4.7619
15	Fabaceae	14	16.6667
16	Lamiaceae	3	3.5714
17	Lythraceae	1	1.1905
18	Malvaceae	2	2.3810
19	Meliaceae	1	1.1905
20	Mimosaceae	1	1.1905
21	Moraceae	2	2.3810
22	Moringaceae	1	1.1905
23	Myrtaceae	1	1.1905
24	Nyctaginaceae	1	1.1905
25	Orobanchaceae	1	1.1905
26	Papaveraceae	2	2.3810
27	Pedaliaceae	1	1.1905
28	Phyllanthaceae	2	2.3810
29	Poaceae	4	4.7619
30	Polygonaceae	1	1.1905
31	Primulaceae	1	1.1905
32	Rhamnaceae	1	1.1905
33	Rutaceae	1	1.1905
34	Salvadoraceae	1	1.1905
35	Solanaceae	6	7.1429
36	Verbenaceae	1	1.1905
37	Zygophyllaceae	1	1.1905

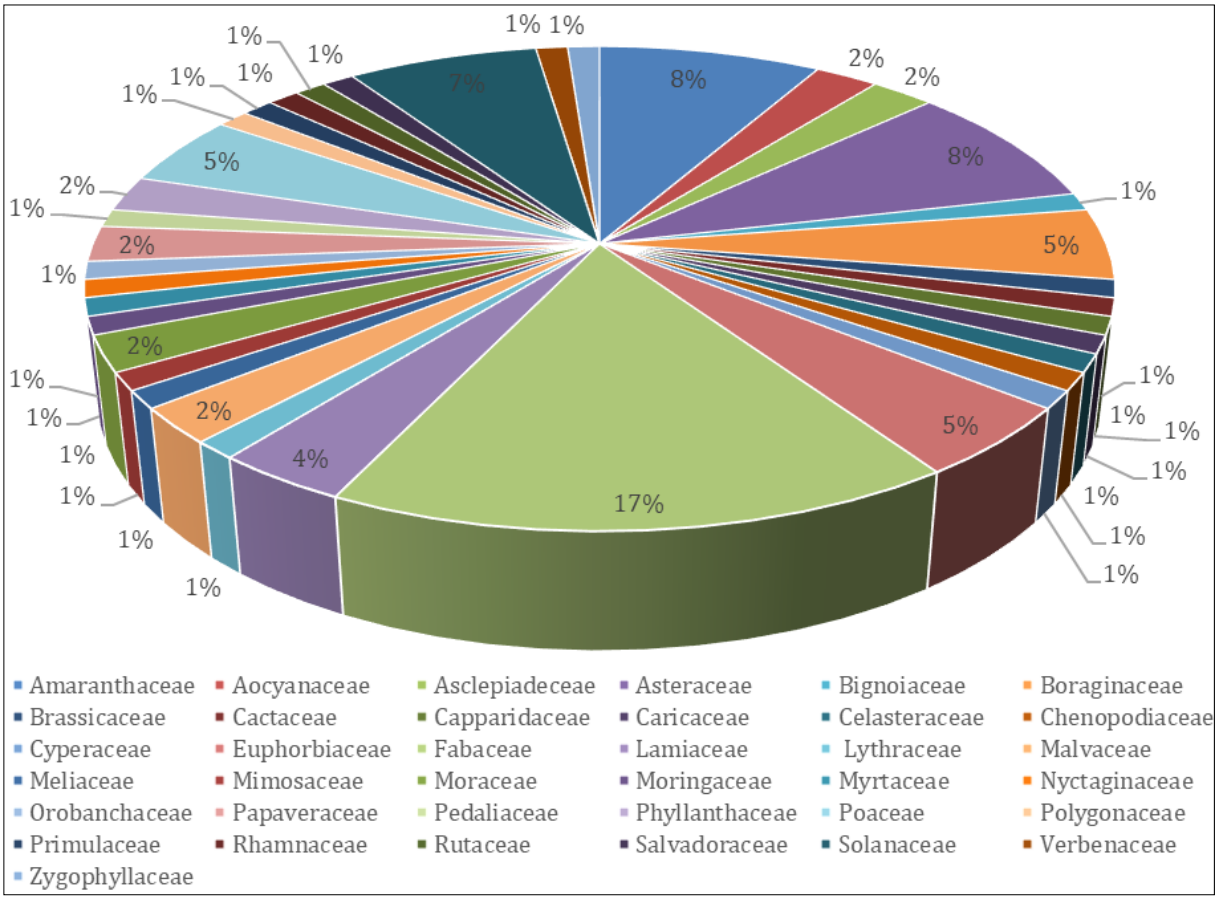

Fig 3: Family-wise distribution of the plants

Habit-wise abundance and distribution of plants in Narhad conservation forest region

The results in Table 3 as well as the corresponding pie chart show habit-wise abundance and distribution of plants in Narhad conservation forest region region over a period of it can be inferred that maximum plants belonged to the category of herbs (33.33%) followed by shrubs and trees (29.76% each), undershrubs (5.95%) and climbers (1.19%).

Table 3: Habit-wise distribution of plants in the study area

Serial No.	Name of habit	Number of plants	% Distribution
1	Climber	1	1.190
2	Herb	28	33.333
3	Shrub	25	29.762
4	Tree	25	29.762
5	Undershrub	5	5.952

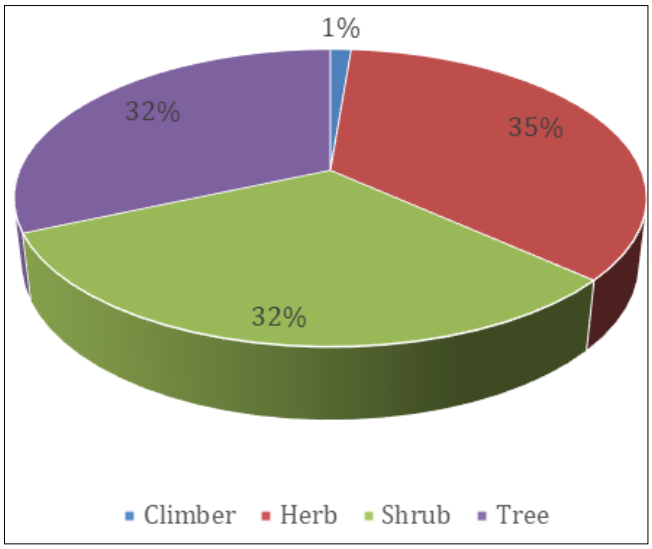

Fig 4: Habit-wise distribution of plants

Habit-wise percentage of species distributed according to Raunkier's frequency classes

The results in Table 4 show habit-wise percentage of species distributed according to Raunkier's frequency classes. As per the results shown, following inferences can be drawn:

- Class A with class frequency of (0-20%) contained nearly all the climbers (100%), 89.286% of herbs, 56% of shrubs, 92% of trees and 80% of undershrubs.
- Class B with class frequency of (20-40%) contained 10.714% of herbs, 44% of shrubs, 8% of trees and 20% of undershrubs.
- Class C, D and E with class frequency of (40-60%), (60-80%) and (80-100%) were devoid of any plants.

Table 4: Habit-wise percentage of species distributed according to Raunkier's frequency classes

Habit	Class A	Class B	Class C	Class D	Class E
Climber	100	0	0	0	0
Herb	89.286	10.714	0	0	0
Shrub	56	44	0	0	0
Tree	92	8	0	0	0
Undershrub	80	20	0	0	0

These frequency classes are A (0%-20%), B (21%-40%), C (41%-60%), D (61%- 80%), E (81%- 100%)

Discussion

Apart from the human race, the environment that we inhabit also provides niche to a huge plethora of other living organisms including plants, animals and micro-organisms, all of which make this planet earth a beautiful place to flourish and form a part of the cyclic process that aids in sustenance of life. The huge biodiversity present on earth extends from even drop of water harboring zillions of microbes to the mighty rainforests, oceans and mountains. Plants form an integral component of the ecosystem and being the primary producers as well as the recipients of the attribute to impart oxygen that sustains life on earth, plants form an indispensable part of the ecosystem, that alone drive the perpetuation of human as well as animal life on earth. Apart from acting as the primary producers owing to their ability to photosynthesize and the oxygen furnishers, plants form a rich storehouse of the bioactive secondary metabolites, that hold great nutritional as well as medicinal value and play a pivotal role in amelioration of human race by equipping us in this incessant fight against the diseases causing pathogens (Hussein *et al.*, 2019; Kabera *et al.*, 2014; Wink, 2015; Bhatti *et al.*, 2022) [8, 11, 28, 2]. India is considered as one of the richest nations when we discuss the topic of biological diversity. The Indian subcontinent harbors a huge myriad of plants as well as animals, which form an integral part of the rich biodiversity of India. However, talking about a huge country like India, which comprises of 28 states and 8 union territories, the current study talks about the rich biodiversity of Narhar conservation forest region of Chirawa, located in Jhunjunu district of Rajasthan.

Apart from its rich cultural heritage as well as age-old forts, Rajasthan is well renowned for its rich biodiversity for inhabiting innumerable species of plants. However, the plant biodiversity of this area has declined considerably in the last few decades owing to abrupt increase in anthropogenic activities as a direct consequence of industrialization and urbanization (Jeph *et al.*, 2019; Gehlot *et al.*, 2016; Rathoure *et al.*, 2020; Islam *et al.*, 2011) [10, 4, 20, 9]. Infact, the results showcased in the study indicate gradual decline in population of plants belonging to several categories, namely, herbs, shrubs, trees, undershrubs and climbers; with maximum decline seen in population of trees, herbs and shrubs. Most of the trees whose population frequency was found to be lowest (10) belonged to the family Fabaceae, while no such trend was seen in case of herbs, shrubs or undershrubs. Talking about the comparative population distribution of different categories of plants, the researchers in this study used a cumulative parameter termed as importance value index (IVI), which is calculated on the basis of relative frequency, relative density and relative abundance (Halmy *et al.*, 2015; Razavi *et al.*, 2012; Prasertsri *et al.*, 2021) [6, 22, 17]. As per the results depicted in the study, the highest IVI was observed in case of *Orobanche ramosa L.* and *Zizyphus mauritiana.* Looking at the results as a whole, the highest values of IVI were observed in case of shrubs followed by herbs and undershrubs, while the lowest IVI values were seen in case of trees.

The next section of the study shows family wise distribution of plants, wherein highest number of plants was found to be belonging to Fabaceae followed by Amaranthacea, Asteraceae, Solanaceae, Boraginaceae, Euphorbiaceae, Poaceae, Apocynaceae, Asclepiadeceae, Malvaceae, Moraceae, Papaveraceae, Phyllanthaceae, Bignoniaceae,Brassicaceae, Cactaceae, Capparidaceae, Caricaceae, Celasteraceae,Chenopodiaceae, Cyperaceae, Lythraceae, Meliaceae, Mimosaceae,Moringaceae,Myrtaceae, Nyctaginaceae, Orobanchaceae, Pedaliaceae,Polygonaceae, Primulaceae, Rhamnaceae, Rutaceae, Salvadoraceae, Verbenaceae and Zygophyllaceae. The study also highlights that maximum number of plants in the study area belonged to the category of herbs (33.33%) followed by shrubs and trees (29.76% each), undershrubs (5.95%) and climbers (1.19%). Furthermore, as per the Raunkier's frequency classes, most of the plants in the study area belonged to class A with class frequency of (0-20%) followed by Class B with class frequency of (20-40%); while no plants were observed in Class C, D and E with class frequency of (40-60%), (60-80%) and (80-100%).

The results showcased in the study are somewhat alarming and shed light on the pathetic situation of plant biodiversity

in Rajasthan. The results indicate decline in population and frequency of certain plants, namely, *Aegle marmelos (L.) Corrêa, Calotropis procera, Datura metel, Eucalyptus camaldulensis, Lawsonia inermis L., Ricinus communis* (frequency =20), *Azadirachta indica A.Juss., Catheranthus roseus, chenopodium album, Chenopodium murale, Datura innoxia, Moringa oleifera Lam., Salvadora oleoides, Salvadora persica, Senna hirsuta (L.) and Senna siamea (Lam.)* (frequency =10). All these plants species have been reported to hold extreme medicinal significance since they harbor a huge range of bioactive secondary metabolites such as phenolics, polyphenolics, terpenoids, flavonoids, coumarins and other secondary metabolites (Velu *et al*., 2018; Mendoza *et al*., 2018; Sen *et al*., 2015) [27, 14, 24]. All these plants and their extracts play a crucial ameliorative role in alleviation of chronic human illnesses characterized by oxidative unequilibrium and inflammatory outbursts (Heinrich *et al.*, 2021; Rungsung *et al.*, 2015) [7, 23]. Not only this, the results showcased in the study depict presence of *Withania somnifera,* commonly referred to as Ashwagandha and enlisted in the category of endangered plants as per the IUCN (Islam *et al.*, 2017). *Withania sominifera* known for its extremely important medicinal value including usage as antimicrobial, anti-inflammatory, antitumor, anti-arthritic, immunomodultory, cardioprotective, hepatoprotective and anti-diabetic agents (Dar *et al*., 2015; Kumar *et al.*, 2015) [3, 12].

The results also show presence of *Prosopis juliflora,* an invasive species introduced from Carribean, Central and northern south America, whose introduction led to decline in number of native plant species, owing to a number of reasons

- Invasive species directly compete with native species for the thereby depriving the native species of their share of nutrients, leading to decline in numbers of native plant species.
- Interaction of invasive species with the resident microbes in the rhizosphere of native species, thereby disrupting the microbial-plant interaction and retarding plant growth and metabolism.
- Emergence of diseased condition that may retard the growth and metabolism of the native species (Sivakumar *et al.*, 2018; Pandey *et al.*, 2019) [26, 15].

In addition to this, several other factors have contributed to decline in plant biodiversity in the state of Rajasthan as well as Indian subcontinent, which include,

- Habitat fragmentation owing to anthropogenic activities like mining, cultivation of agricultural crops, construction of factories and households. This leads to geographical isolation of the plan species; thereby separating them from other plants whose survival is interdependent.
- Overharvesting and overexploitation by humans at a rate much faster than the recovery rate of plants
- Soil erosion and deforestation leading to loss of ecological niche of plants harboring the useful microbes necessary for plant sustenance
- Global climate change and pollution leading to decreased photosynthesis, reduced nutrient uptake, weakened plant immunity and early ageing (Giam *et al.*, 2010; Sharma *et al.*, 2022) [5, 25]

Therefore, the current study is a reminder to conserve the pivotal resources bestowed upon us by Mother Nature in the form of plants. Considering the current state of affairs, if the biodiversity extinction continues to occur at this rate, the day is not far off when all forms of life will cease to exist on earth. In this context, setting up of conservation reserves like Narhad conservation forest region by state and central governments is a crucial step towards amelioration of the pathetic situation. However, apart from the government agencies, common people participation is needed to make this endeavour successful towards achieving a harmonious homeostatic society for all forms of living beings.

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