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Diversity of Plant Species in Lal Suhanra National Park, Bahawalpur, Pakistan

Mansoor Hameed, [1]A. Aleem Chaudhry, M. Anwar Maan, Anwar H. Gill
Department of Botany, University of Agriculture, Faisalabad, Pakistan
[1]Punjab Wildlife Research Institute, Gatwala, Faisalabad, Pakistan

Abstract: For phytosociological studies of Lal Suhanra National Park, Bahawalpur five vegetation study sites viz., old irrigated plantation, new irrigated plantation, natural vegetation within old demarcated desert area, new demarcated desert area and Patisar Lake area were evaluated on the bases of varied ecological conditions. Old irrigated plantations consisted of mixed species plantations, mostly of *Dalbergia sissoo*, *Acacia nilotica* and *Eucalyptus camaldulensis*. Forest plantations had specific type of flora, consisted of *Prosopis glandulosa*, *Saccharum bengalense* and *Imperata cylindrica*. New irrigated plantation possessed mixed type plantations but monocultures of *Dalbergia sissoo* and sometimes *Eucalyptus camaldulensis* are practiced in few blocks. The ground flora comprised of agriculture weed like *Conyza ambigua*, *Desmostachya bipinnata*, *Imperata cylindrica* and tall grasses like *Saccharum bengalense* and *Saccharum spontaneum* with few native trees/large shrubs like *Tamarix aphylla* and *Prosopis cineraria*. Dense plantations almost totally eliminated the ground flora, perhaps due to poor light intensity and last-seasoned non-decomposed plant material of deciduous trees. Natural vegetation is of desertic nature consisted of *Acacia jacquemontii*, *Haloxylon recurvum*, *Lasiurus scindicus*, *Ochthochloa compressa* and *Prosopis cineraria*. Habitat diversity was the maximum in demarcated area, containing saline or sodic patches, low sand dunes and sandy clayey soils. *Aeluropus lagopoides*, *Cymbopogon jwarancusa* and *Suaeda fruticosa* generally confined to saline soils. *Ochthochloa compressa*, *Tamarix dioica*, *Cymbopogon jwarancusa* and *Prosopis cineraria* restricted to interdunal sandy clayey soils and *Aristida adscensionis*, *Calligonum polygonoides*, *Lasiurus scindicus* and *Haloxylon recurvum* were typified to sandy habitat. Non-demarcated area showed high grazing pressure, the vegetation was more or less shrubby, but clusters of grasses like *Cenchrus pennisetiformis*, *Cymbopogon jwarancusa* and *Lasiurus scindicus* can be seen. Dominant species among dicots were *Calligonum polygonoides*, *Dipterygium glaucum*, *Leptadenia pyrotechnica*, *Haloxylon recurvum* and *Salsola baryosma*. Vegetation inside the Patisar Lake was dominated by *Phragmites karka* and *Typha domingensis* at shallow water whereas, *Nelumbo nucifera* and *Vallisneria spiralis* in the deeper waters. *Cynodon dactylon* with *Phyla nodiflora* dominated the bank but tussocks of *Saccharum spontaneum* and *Saccharum bengalense* were also recorded. The habitat has the ample potential to support a number of wildlife species including game species like waterfowl, grey and black francolins, houbara bustard and sand grouses.

Key words: Lal Suhanra National Park, phytosociological studies, habitat

Introduction

Lal Suhanra National Park lies in the southeastern part of the Punjab Province, about 32 km east of Bahawalpur and 2 km south of Lal Suhanra railway station (Fig. 1). The park is located between 29°12′ and 29°28′N and 71°48′ and 72°08′E at an altitude of 125-140 m above sea level. More than 99 % of the park is located in Bahawalpur Tehsil, while a small portion of the northeast corner is in Khairpur Tamiwali Tehsil. The area was declared a national park on 26 October 1972 under the Punjab Wildlife (Protection, Preservation, Conservation and Management) Ordinance 1972. The Park is spread over an area of 515.90 km^2, including four basic ecosystem types, i.e., irrigated forest plantation (103.76 km^2), Patisar Lake (23.65 km^2), old demarcated desert area (255.88 km^2) and new demarcated desert area (247.35 km^2).

The climate of the area is of sub-tropical continental type, characterized by low and sporadic rainfall, high temperatures, low relative humidity, high rate of evaporation and strong summer winds. Temperature ranges from 50°C during summer to -2°C during winter and the hottest months are May and June. Annual rainfall varies between 90 to 200 mm and relative humidity is about, 60%. Wind direction in summer is southeastern and in winter it is northeastern.

The soil in general is made up of alluvial deposits having clayey loam at 'Dahars' (flat areas between dunes) with low sand dunes at scattered places. The size of sand dunes ranges from 0.01 to 0.50 km^2 and up to the height of 6 m. Clayey loam deposits are about 1.5 to 5.0 m thick and pure sand starts below the hard clayey surface.

Important wildlife species of the desert and plantation are blackbuck (*Antilope cervicarpa*), nilgai (*Boselaphus tragocamelus*), chinkara (*Gazella gazella*), hare (*Lepus nigricolis*), jungle fox (*Vulpes benghalensis*), black francolin (*Francolinus francolinus*), grey francolin (*Francolinus pondicerianus*), houbara bustard (*Chlamydotis undulate*), chestnut-belied sandgrouse (*Pterocles exustus*), painted sandgrouse (*Pterocles indicus*), and imperial sandgrouse (*Pterocles orientalis*). Several wintering waterfowl

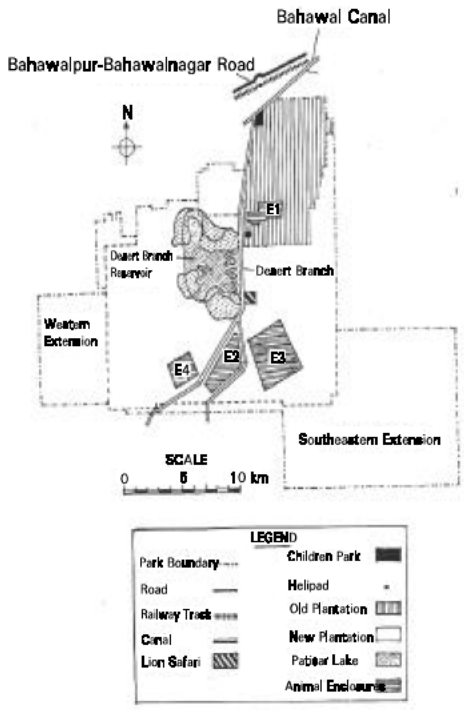


Fig. 1: Lal Suhanra National Park, Bahawalpur

species visit the lake area during winter. Important species are pintail (*Anus acuta*), shoveller (*Anus clypteata*), common teal (*Anus crecca*), widgeon (*Anus penelope*), mallard (*Anus platyrhynchos*), gadwall (*Anus strepera*), purple moorhen (*Porphyrio porphyrio*),

coot (*Fulica atra*), common pochard (*Aythya ferina*) and darter (*Anhinga melanogaster*).

Lal Suhanra National Park is of immense value due to forest plantation, wildlife enclosures, picnic spots and commercial fishing in the fish pond area. The variability of habitat plays an important role in preserving biodiversity of the area. Natural vegetation inside the plantations is of weedy nature while the desert area supports the vegetation of desertic and semi-desertic type. Patisar Lake area has the aquatic or semi-aquatic vegetation that is of submerged, floating or marshy type.

A detailed vegetation survey was undertaken during May 1996 to evaluate plant biodiversity and phytoecology of the area. The investigations were focused on the biodiversity and adaptation of natural flora to a variety of habitat types in irrigated plantations, desertic and semi-desertic habitat type and wetland area.

Materials and Methods

The vegetation survey of Lal Suhanra National Park was conducted in May 1996. Four different vegetation study sites were selected for the phytosociological studies inside the park area (Table 1), keeping in view the major ecotypes. Each study site was divided into different groups on the bases of habitat types. Some of these habitat types were further subdivided into sub-types according to the diverse ecological factors such as soil structure, soil texture and salinity type.

Vegetation was studied by quadrat method. Ten quadrats, each of 10 x 10 m^2 for trees, 5 x 5 m^2 for shrubs and 1 x 1 m^2 for ground cover were laid at each habitat type/sub-type along a straight line. Each 10 x 10 m^2 quadrat was separated from the next one by 10 m. The smaller quadrats were laid at one fixed corner of the 10 x 10 m^2 quadrat. Samples of each plant species were collected for the herbarium. Species were identified following Flora of Pakistan (Nasir and Ali, 1970-90). Density, frequency and cover of each species were recorded and relative values of these parameters were calculated, along with importance value in accordance with Hussain (1983). Vegetation inside and around the Patisar Lake was categorized according to their density class (i.e., rare, occasional, frequent, abundant and dominant) on the bases of visual observations.

Results and Discussion

Vegetation: After an exploration of the total area, 56 plant species belonging to 20 families were recorded (Table 2). The largest family was Poaceae with 19 grass species including saline tolerant species like *Aeluropus lagopoides* and *Ochthochloa compressa*, semi-desertic species like *Aristida hystricula, Aristida mutabilis* and *Sporobolus ioclados*, true desertic species like *Aristida adscensionis, Lasiurus scindicus, Ochthochloa compressa* and *Panicum antidotale*. Important species in the irrigated plantations were *Saccharum bengalense, Desmostachya bipinnata, Dichanthium annulatum* and *Imperata cylindrica*.

The second largest families were Chenopodiaceae and Mimosaceae, containing four species each, whereas, Amaranthaceae, Euphorbiaceae and Papilionaceae with three species each. Dominant species among the trees were planted forest species like *Dalbergia sissoo, Eucalyptus camaldulensis* and *Acacia nilotica*. Native tree species were *Tamarix aphylla, Tamarix dioica* and *Salvadora oleoides*. Important shrub species were *Leptadenia pyrotechnica, Capparis decidua, Prosopis glandulosa, Prosopis cineraria, Acacia jacquemontii* and *Calligonum polygonoides*. Herbaceous or small shrubby species like *Diclyptera bupleuroides, Achyranthes aspera, Amaranthus viridis, Abutilon indicum, Conyza ambigua, Eclipta alba, Euphorbia granulata, Euphorbia hirta, Datura fastuosa* and *Withania somnifera* only confined to irrigated plantations. *Aerva javanica, Heliotropium crispum, Cressa cretica, Haloxylon salicornicum, Haloxylon recurvum, Suaeda fruticosa, Salsola baryosma, Euphorbia prostrata* and *Fagonia indica* were among natural desert vegetation.

Phytosociological studies: Five vegetation study sites were selected on the basis of major ecological zones within the national park area. Results of the phytoecological studies are presented as under:

Old irrigated plantation (site 1): Old irrigated plantation mostly comprised of mixed type of forest trees like *Dalbergia sissoo, Acacia nilotica* and *Eucalyptus camaldulensis*. Three habitat types were selected within this study site (Table 3).

Irrigated forest plantation: *Eucalyptus camaldulensis* and *Dalbergia sissoo* dominated the area where 18 plant species were recorded. Large trees and shrubs like *Dalbergia sissoo, Eucalyptus camaldulensis, Prosopis cineraria, Prosopis glandulosa* and *Calligonum polygonoides* characterized the habitat. Ground flora consisted of typical grasses of forest plantations like *Cenchrus pennisetiformis, Dichanthium annulatum, Imperata cylindrica* and *Saccharum bengalense*, but invasion of desert grass, *Ochthochloa compressa*, was also recorded in few patches. Small herbs or under shrubs like *Achyranthes aspera, Alhagi maurorum, Diclyptera bupleuroides, Heliotropium crispum* and *Salsola baryosma* were also reported at some scattered places.

Natural vegetation inside wildlife enclosure: Soil of the habitat type was silt to sandy loam, supporting 14 plant species. *Lasiurus scindicus* community with *Cymbopogon jwarancusa* and *Ochthochloa compressa* patches in scattered places dominated the vegetation. *Acacia jacquemontii, Prosopis cineraria* and *Calligonum polygonoides* were the dominant species among shrubs along with a single tree species *Salvadora oleoides*. Vegetation was rich in palatable grass species like *Lasiurus scindicus, Cymbopogon jwarancusa* and *Aristida adscensionis*, especially at earlier stages of growth (Khan, 1957).

Natural vegetation outside the enclosure: Nine plant species were recorded in the area that was dominated by *Ochthochloa compressa* community. Other important species were *Acacia jacquemontii, Prosopis cineraria, Calligonum polygonoides, Capparis decidua, Lasiurus scindicus* and *Haloxylon recurvum*. Herbaceous vegetation is almost lacking, but a mixture of shrubs and grasses was the main feature of this habitat type.

New irrigated plantation (site 2): Forest plantations were selected for site 2, where the plantations were mostly of mixed type. Monoculture plantations were in some compartments, composed of *Dalbergia sissoo* and *Eucalyptus camaldulensis* (Table 4).

Forest plantation inside the enclosure (Mixed plantation): Thirty plant species were recorded from the area where plantation mainly comprised of *Dalbergia sissoo* but other trees like *Acacia nilotica* and *Tamarix dioica* were also present in small numbers. Ground cover mostly comprised of grasses. Dominant species were *Cenchrus pennisetiformis, Cymbopogon jwarancusa, Cynodon dactylon, Imperata cylindrica, Lasiurus scindicus, Ochthochloa compressa, Saccharum bengalense* and *Saccharum spontaneum*. A fair number of herbaceous/shrubby species was also recorded; however, *Prosopis cineraria, Alhagi maurorum, Conyza ambigua* and *Euphorbia prostrata* were the dominant species.

Forest plantation outside the enclosure (*Dalbergia sissoo*): The habitat supported 20 plant species in the community *Imperata cylindrica-Dalbergia sissoo*. The only planted species was *Dalbergia sissoo* but the area was dominated by typical weeds of forest plantations like *Imperata cylindrica* and *Desmostachya bipinnata*, along with natural tree/shrub species like *Tamarix dioica*. Grasses such as *Cenchrus pennisetiformis, Dichanthium annulatum, Saccharum bengalense* and *Saccharum spontaneum*, herbs like *Suaeda fruticosa* and shrubs like *Prosopis cineraria* were also frequently recorded.

Forest plantation outside enclosure (Mixed plantation): Only six plant species were recorded in the area where there was a dense

plantation composed of three forest tree species, *Dalbergia sissoo*, *Eucalyptus camaldulensis* and *Acacia nilotica*. Naturally occurring species were *Prosopis cineraria*, recorded in fair numbers but two species *Tamarix aphylla* and *Tamarix dioica* were very rare. The ground cover was totally missing, perhaps due to dense plantation and non-degraded leaf material.

Natural vegetation in new irrigated plantation (site 3): Site 3 was also selected within the new irrigated plantations but the habitat was confined to unplanted patches of desert/semidesert type. Soil, in general, was sandy to sandy clay with some saline patches, particularly at interdunal area (Table 5).

Vegetation inside the enclosure (saline/ sodic soil): Hard crest of the soil in this habitat type supported only eight plant species most of which were highly salinity tolerant. The dominant species were *Suaeda fruticosa* and *Aeluropus lagopoides*. *Cymbopogon jwarancusa* was also quite frequently recorded but only in patches where soil surface was somewhat sandy. Palatable grass species like *Aeluropus lagopoides*, *Cymbopogon jwarancusa* and *Panicum antidotale* were frequent whereas shrubby vegetation like *Capparis decidua* and *Acacia jacquemontii* were found scattered.

Vegetation inside the enclosure (sandy soil): Sandy soil with about 1-2m high sand dunes was a feature of this habitat, containing eleven plant species. Vegetation of the area was integrally dominated by *Lasiurus scindicus*. Grasses like *Aristida adscensionis* (on sand dunes) and *Ochthochloa compressa* and *Cymbopogon jwarancusa* (interdunal areas) were seen in bunches. All other grasses recorded from this habitat type were palatable. These were *Ochthochloa compressa*, *Lasiurus scindicus*, *Cenchrus pennisetiformis*, *Stipagrostis plumosa*, *Cymbopogon jwarancusa*, *Aristida hystricula* and *Aristida adscensionis*. Shrubby vegetation included *Calligonum polygonoides* and *Prosopis cineraria* while *Salsola baryosma* and *Haloxylon recurvum* were occasionally recorded under shrubs.

Vegetation outside the enclosure (Sandy to sandy clay): This habitat type is the richest with regard to species diversity in study site 3. Thirteen plant species were encountered in the area in *Suaeda fruticosa-Ochthochloa compressa* community. Among tall vegetation (trees and shrubs) frequent species were *Prosopis cineraria* and *Tamarix dioica*, whereas, *Acacia nilotica* and *Tamarix aphylla* were rarely recorded. Grasses like *Panicum turgidum*, *Ochthochloa compressa*, *Cymbopogon jwarancusa*, *Aristida adscensionis* and *Sporobolus ioclados* dominated the ground cover vegetation. *Fagonia indica*, *Haloxylon salicornicum* and *Suaeda fruticosa* were the small dicot species, the dominant one was *Suaeda fruticosa*, recorded on the hard clay crest only.

Demarcated desert area (site 4): Non-demarcated area was transferred to the National Park in 1984 where high grazing pressure exists. No attempt has so far been made to plant up the area. Sandy clay or silt clay soils were found in the interdunal area; sand dunes being 1-5 m high interspersed in the area (Table 6).

Interdunal area containing sand dunes up to 2 m high: Fourteen species were found in this habitat type, the vegetation was completely dominated by *Aristida adscensionis* community. Other grasses such as *Cenchrus pennisetiformis*, *Cymbopogon jwarancusa*, *Lasiurus scindicus*, *Ochthochloa compressa* and *Stipagrostis plumosa* were rarely seen. *Acacia jacquemontii*, *Calligonum polygonoides* and *Leptadenia pyrotechnica* were the dominant shrubs but other dicots such as *Crotalaria burhia*, *Dipterygium glaucum*, *Haloxylon recurvum* and *Heliotropium crispum* were very rare. All the grasses recorded within the area were palatable.

Sand dunes up to 5 m high: Twelve species, highly drought resistant, were recorded from the area in the *Cymbopogon jwarancusa-Lasiurus scindicus* vegetation community. The habitat type supported three grasses and two herbs, while the other species were shrubs or trees; dominant among them were *Calligonum polygonoides*, *Prosopis cineraria* and *Tamarix aphylla*.

Interdunal area with saline patches: Ten plant species were recorded in the *Calligonum polygonoides-Haloxylon recurvum* community where the vegetation was mostly of shrubby type. Only two grasses, *Aristida adscensionis* and *Cenchrus pennisetiformis* were seen in the area in infrequent number. *Acacia jacquemontii*, *Calligonum polygonoides*, *Capparis decidua* and *Leptadenia pyrotechnica* were the dominant tall shrubs while herb/undershrub species were rare except *Haloxylon recurvum*. High grazing pressure resulted in the massive loss of palatable grasses from this habitat type.

Patisar Lake area

Aquatic vegetation: *Vallisneria spiralis*, *Typha domingensis*, *Phragmites karka* and *Nelumbo nucifera* were recorded inside the fishpond. *Typha domingensis* and *Phragmites karka*, the tall perennials, completely invaded the shallow water habitat. Deeper water were dominated by *Nelumbo nucifera*.

Vegetation of the lake border: Dense cover of Cynodon dactylon occupied the bank area, but *Phyla nodiflora* shared the habitat in small patches with its creeping nature. Tall tussocks of *Saccharum bengalense*, *Saccharum spontaneum* were recorded frequently.
The only dominant shrubby species, *Calotropis procera*, was recorded from the habitat type.

Discussion

Old irrigated plantations composed of both monocultures and mixed plantations, particularly of *Eucalyptus camaldulensis*, *Dalbergia sissoo* and *Acacia nilotica*. Many plant species are restricted to the plantations only; most of them are agricultural weeds. Important species were *Achyranthes aspera*, *Alhagi maurorum*, *Dichanthium annulatum*, *Diclyptera bupleuroides*, *Heliotropium crispum*, *Imperata cylindrica* and *Saccharum bengalense* (Fig. 2). Plantation area contained more species diversity and vegetation cover than the natural desertic areas, where the habitat consisted of few dominant species. The species specific to loamy soils were *Aristida mutabilis*, *Cymbopogon jwarancusa*, *Lasiurus scindicus*, *Fagonia indica*, *Aerva javanica* and *Salvadora oleoides*, whereas, *Aristida adscensionis*, *Ochthochloa compressa*, *Acacia jacquemontii*, *Calligonum polygonoides*, *Capparis decidua*, *Haloxylon recurvum* and *Prosopis cineraria* dominated the habitat with higher sand components.
Species diversity in the new irrigated forest plantations was substantially high in the fenced mixed plantation than in unfenced area outside the wildlife enclosure. *Dalbergia sissoo* plantation also possessed high species diversity but the cover was completely dominated by only few species such as *Imperata cylindrica* and *Desmostachya bipinnata*. Mixed plantation outside the wildlife enclosure had very dense cover of *Dalbergia sissoo*, *Acacia nilotica* and *Prosopis cineraria* showing the least species diversity in the habitat type. The ground cover is almost completely absent, might be due to very dense canopy cover and non-decomposed litter which is a limitation to other species, especially herbs and undershrubs.
Natural vegetation occupied the desert or semidesert area within new irrigated plantations depicting considerable low species diversity than in irrigated plantations. Saline soils contained peculiar vegetation like *Aeluropus lagopoides*, *Cymbopogon jwarancusa* and *Suaeda fruticosa*. Sandy soils had typical desertic and semidesertic vegetation, dominated by *Aristida adscensionis*, *Calligonum polygonoides*, *Cenchrus pennisetiformis* and *Lasiurus scindicus*, but *Cymbopogon jwarancusa*, *Ochthochloa compressa*, *Sporobolus ioclados*, *Suaeda fruticosa* and *Tamarix dioica* were the specific species of sandy clay. New demarcated desert area on the eastern and western sides is comprised of sand dunes and interdunal area, where the human influence is quite visible. The area was rich in shrubby vegetation but grasses like *Lasiurus*

Table 1: Vegetation study sites and habitat types of Lal Suhanra National Park

Study site	Habitat type	Cover (%)	Number	Soil types of species	Plant community
Old irrigated plantation	Forest plantation (Mixed plantation)	84	18	Sandy clay	*Eucalyptus camaldulensis*
	Natural vegetation inside the enclosure	37	15	Silt to sandy loam	*Lasiurus scindicus*
	Natural vegetation outside the enclosure	36	9	Sandy clay	*Ochthochloa compressa*
New irrigated plantation	Forest plantation inside the enclosure (Mixed plantation)	79	20	Sandy loam	*Dalbergia sissoo*
	Forest plantation outside the enclosure (*Dalbergia sissoo*)	95	30	Sandy loam	*Imperata cylindrica-Tamarix dioica-Dalbergia sissoo*
	Forest plantation outside the enclosure (Mixed plantation)	62	5	Sandy loam	*Dalbergia sissoo*
Natural vegetation in old demarcated area	Inside the enclosure	18	8	Saline/sodic	*Suaeda fruticosa*
	Inside the enclosure	33	11	Sand	*Lasiurus scindicus*
	Outside the enclosure	32	13	Sandy clay	*Ochthochloa compressa*
Natural vegetation in demarcated area	Interdunal area containing sand dunes up to 2m high (western side)	38	14	Sandy loam new	*Aristida adscensionis*
	Sand dunes up to 5m high (western side)	18	12	Sand	*Cymbopogon jwarancusa-Lasiurus scindicus-Calligonum*
	Interdunal area with saline patches (eastern side)	27	10	Saline/sandy clay	*Calligonum polygonoides-Haloxylon recurvum*
Patisar lake area	Aquatic vegetation	Not recorded			
	Surrounding vegetation	Not recorded			

Table 2: Plant species recorded at Lal Suhanra National Park during May 1996

Family	Species (Number)	Plant species
Acanthaceae	1	*Diclyptera bupleuroides*
Amaranthaceae	3	*Achyranthes aspera, Aerva javanica, Amaranthus viridis*
Asclepiadaceae	2	*Calotropis procera, Leptadenia pyrotechnica*
Boraginaceae	2	*Heliotropium crispum, Lappula spinocarpos*
Capparidaceae	2	*Capparis decidua, Dipterygium glaucum*
Chenopodiaceae	4	*Haloxylon recurvum, Haloxylon salicornicum, Salsola baryosma, Suaeda fruticosa*
Compositae	2	*Conyza ambigua, Eclipta alba*
Convolvulaceae	1	*Cressa cretica*
Cyperaceae	1	*Cyperus rotundus*
Euphorbiaceae	3	*Euphorbia granulata, Euphorbia hirta, Euphorbia prostrata*
Hydrocharitaceae	1	*Vallisneria spiralis*
Malvaceae	1	*Abutilon indicum*
Mimosaceae	4	*Prosopis cineraria, Prosopis glandulosa, Acacia jacquemontii, Acacia nilotica*
Myrtaceae	1	*Eucalyptus camaldulensis*
Nymphaeaceae	1	*Nelumbo nucifera*
Papilionaceae	3	*Alhagi maurorum, Crotalaria burhia, Dalbergia sissoo*
Poaceae	19	*Aeluropus lagopoides, Aristida adscensionis, Aristida hystricula, Aristida mutabilis, Cenchrus pennisetiformis, Cymbopogon jwarancusa, Cynodon dactylon, Desmostachya bipinnata, Dichanthium annulatum, Imperata cylindrica, Lasiurus scindicus, Ochthochloa compressa, Panicum antidotale, Panicum turgidum, Phragmites karka, Saccharum bengalense, Saccharum spontaneum, Sporobolus ioclados, Stipagrostis plumosa*
Polygonaceae	1	*Calligonum polygonoides*
Salvadoraceae	1	*Salvadora oleoides*
Solanaceae	2	*Datura fastuosa, Withania somnifera*
Tamaricaceae	2	*Tamarix aphylla, Tamarix dioica*
Typhaceae	1	*Typha domingensis*
Verbenaceae	1	*Phyla nodiflora*
Zygophyllaceae	1	*Fagonia indica*

Table 3: Ecological studies of plant species recorded at old irrigated plantation (Site 1)

	Forest plantation (Mixed plantation)			Natural vegetation Inside the enclosure			Natural vegetation outside the enclosure		
Plant species	R.D.	R.C.	R.F.	R.F.	R.D.	R.C.	R.F.	R.D.	R.C.
Achyranthes aspera	0.3	1.8	0.1	---	---	---	---	---	---
Acacia jacquemontii	---	---	---	10.6	1.3	5.8	8.3	1.0	31.3
Aeluropus lagopoides	0.3	1.8	0.1	---	---	---	---	---	---
Aerva javanica	---	---	---	4.3	0.5	0.1	---	---	---
Alhagi maurorum	7.6	8.9	1.1	---	---	---	---	---	---
Aristida adscensionis	---	---	---	2.1	1.3	0.3	6.3	5.8	9.4
Aristida mutabilis	---	---	---	4.3	3.7	0.8	---	---	---
Calligonum polygonoides	14.9	8.3	23.3	---	---	---	1.0	3.2	7.5
Capparis decidua	1.0	3.6	0.1	---	---	---	2.1	0.1	10.4
Cenchrus pennisetiformis	2.3	3.6	0.1	---	---	---	2.1	0.1	0.5
Crotalaria burhia	---	---	---	2.1	0.3	0.1	---	---	---
Cymbopogon jwarancusa	---	---	---	8.5	8.6	8.5	---	---	---
Dalbergia sissoo	13.2	10.7	9.0	---	---	---	---	---	---
Dichanthium annulatum	3.6	3.6	0.1	---	---	---	---	---	---
Diclyptera bupleuroides	1.7	1.8	0.3	---	---	---	---	---	---
Eucalyptus camaldulensis	39.1	17.9	80.1	---	---	---	---	---	---
Fagonia indica	---	---	---	2.1	0.3	0.1	---	---	---
Haloxylon recurvum	---	---	---	4.3	1.1	1.5	20.8	6.1	5.0
Heliotropium crispum	2.0	1.8	0.3	---	---	---	---	---	---
Imperata cylindrica	1.0	3.6	0.2	---	---	---	---	---	---
Lappula spinocarpos	---	---	---	2.1	0.3	0.1	---	---	---
Lasiurus scindicus	1.7	1.8	0.3	21.3	59.9	38.9	14.6	7.5	4.3
Ochthochloa compressa	11.6	5.4	1.1	8.5	11.2	6.0	18.8	75.9	10.6
Prosopis cineraria	6.0	14.3	2.5	6.4	2.1	11.0	6.3	0.3	20.9
Prosopis glandulosa	7.6	14.3	4.0	2.1	0.3	0.1	---	---	---
Saccharum bengalense	0.3	1.8	0.1	---	---	---	---	---	---
Salsola baryosma	0.3	1.8	0.1	---	---	---	---	---	---
Salvadora oleoides	---	---	---	6.4	0.8	3.3	---	---	---

R.D. = Relative density, R.F. = Relative frequency, R.C. = Relative cover

Table 4: Ecological studies of plant species recorded at new irrigated plantation (Site 2)

	Forest plantation inside the enclosure (Mixed plantation)			Forest plantation outside the enclosure (*Dalbergia sissoo*)			Forest plantation outside the enclosure (Mixed plantation)		
Plant species	R.D.	R.F.	R.C.	R.F.	R.D.	R.C.	R.D.	R.F.	R.C.
Abutilon indicum	0.2	1.4	0.1	---	---	---	---	---	---
Acacia nilotica	6.0	8.3	7.5	---	---	---	8.5	26.1	15.2
Aerva javanica	---	---	---	1.6	0.1	0.1	---	---	---
Alhagi maurorum	12.5	6.9	2.0	1.6	0.1	0.1	---	---	---
Amaranthus viridis	0.8	1.4	0.1	---	---	---	---	---	---
Aristida hystricula	0.3	1.4	0.1	---	---	---	---	---	---
Calotropis procera	0.2	1.4	0.1	1.6	0.1	0.2	---	---	---
Capparis decidua	0.2	1.4	0.3	1.6	0.1	0.1	---	---	---
Cenchrus pennisetiformis	22.5	5.6	4.7	1.6	0.1	0.1	---	---	---
Conyza ambigua	3.5	2.8	0.6	1.6	0.1	0.1	---	---	---
Cressa cretica	1.8	1.4	0.6	---	---	---	---	---	---
Cymbopogon jwarancusa	5.3	5.6	1.7	1.6	0.2	0.1	---	---	---
Cynodon dactylon	3.3	1.4	0.6	---	---	---	---	---	---
Cyperus rotundus	0.2	1.4	0.1	---	---	---	---	---	---
Dalbergia sissoo	18.2	12.5	62.2	16.4	4.9	27.5	78.3	43.5	75.3
Datura fastuosa	---	---	---	1.6	0.1	0.1	---	---	---
Desmostachya bipinnata	---	---	---	1.6	17.5	6.9	---	---	---
Dichanthium annulatum	0.8	1.4	0.1	4.9	1.6	0.6	---	---	---
Eclipta alba	0.2	1.4	0.1	---	---	---	---	---	---
Eucalyptus camaldulensis	---	---	---	---	---	---	4.7	4.3	4.8
Euphorbia granulata	---	---	---	1.6	0.1	0.1	---	---	---
Euphorbia hirta	0.2	1.4	0.1	---	---	---	---	---	---
Euphorbia prostrata	3.7	2.8	0.1	1.6	0.1	0.1	---	---	---
Haloxylon recurvum	0.3	1.4	0.1	1.6	0.1	0.1	---	---	---
Haloxylon salicornicum	0.2	1.4	0.1	---	---	---	---	---	---
Imperata cylindrica	1.5	2.8	0.9	16.4	48.8	18.4	---	---	---
Lasiurus scindicus	0.5	2.8	5.1	---	---	---	---	---	---
Ochthochloa compressa	5.8	2.8	1.2	---	---	---	---	---	---
Prosopis cineraria	2.7	6.9	5.1	8.2	1.4	3.9	7.8	21.7	4.3
Prosopis glandulosa	0.2	1.4	0.2	---	---	---	---	---	---
Saccharum bengalense	2.2	6.9	1.0	9.8	3.5	6.9	---	---	---
Saccharum spontaneum	0.5	4.2	1.8	4.9	5.3	6.1	---	---	---
Salvadora oleoides	1.0	2.8	0.1	---	---	---	---	---	---
Suaeda fruticosa	---	---	---	3.3	2.8	1.2	---	---	---
Tamarix aphylla	---	---	---	---	---	---	0.8	4.3	0.3
Tamarix dioica	0.7	4.2	3.6	16.4	12.8	27.7	0.8	4.3	0.3
Withania somnifera	0.2	2.8	0.1	---	---	---	---	---	---

R.D. = Relative density, R.F. = Relative frequency, R.C. = Relative cover

Table 5: Ecological studies of natural vegetation recorded at new irrigated plantation (site 3)

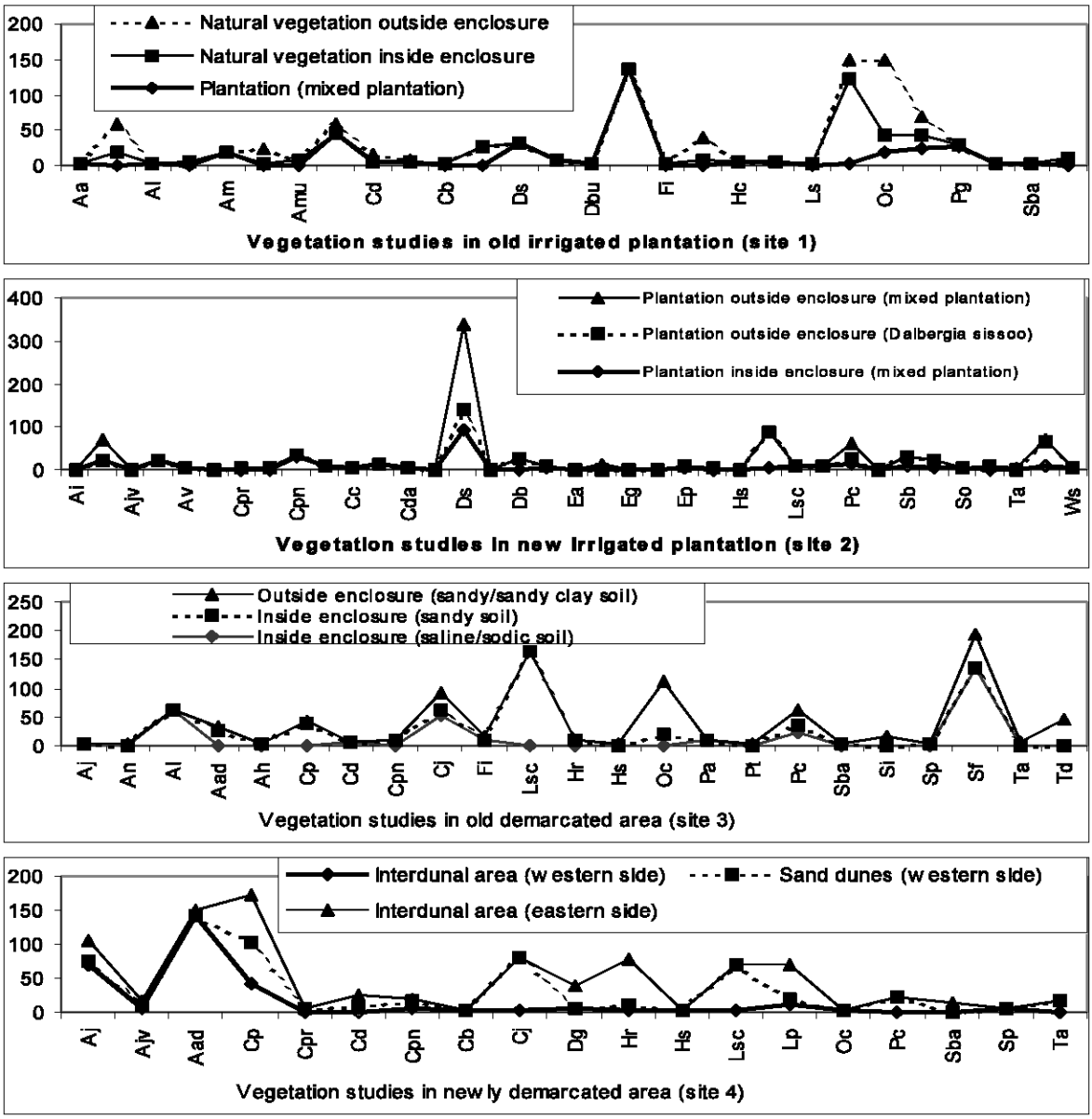
	Natural vegetation inside the enclosure (Saline/sodic soil)			Natural vegetation inside the enclosure (Sandy soil)			Natural vegetation outside enclosure (Sandy / sandy clay)		
Plant species	R.D.	R.F.	R.C.	R.D.	R.F.	R.C.	R.D.	R.F.	R.C.
Acacia jacquemontii	0.3	3.3	0.3	---	---	---	---	---	---
Acacia nilotica	---	---	---	---	---	---	0.2	2.2	0.7
Aeluropus lagopoides	29.3	16.7	15.3	---	---	---	---	---	---
Aristida adscensionis	---	---		12.0	10.3	4.0	1.2	4.3	0.1
Aristida hystricula	---	---		0.2	2.6	0.2	---	---	---
Calligonum polygonoides	---	---		3.4	20.5	15.2	0.2	2.2	1.7
Capparis decidua	0.3	3.3	2.7	---	---	---	---	---	---
Cenchrus pennisetiformis	---	---	---	1.9	7.7	0.5	---	---	---
Cymbopogon jwarancusa	17.0	16.7	18.1	2.8	5.1	2.1	12.4	8.7	9.3
Fagonia indica	2.2	6.7	1.1	---	---	2.4	2.2	0.7	
Lasiurus scindicus	---	---	---	70.8	25.6	67.0	---	---	---
Haloxylon recurvum	---	---	---	1.0	7.7	0.8	---	---	---
Haloxylon salicornicum	---	---	---	---	---	---	0.4	2.2	0.7
Ochthochloa compressa	---	---	---	7.0	10.3	2.4	44.8	21.7	25.8
Panicum antidotale	0.6	6.7	1.1	---	---	---	---	---	---
Panicum turgidum	---	---	---	---	---	---	0.2	2.2	0.3
Prosopis cineraria	1.1	13.3	8.8	0.4	5.1	7.6	2.0	6.5	16.5
Salsola baryosma	---	---	---	0.4	2.6	0.2	---	---	---
Sporobolus ioclados	---	---	---	---	---	---	7.0	10.9	0.1
Stipagrostis plumosa	---	---	---	0.2	2.6	0.2	---	---	---
Suaeda fruticosa	49.2	33.3	52.6	---	---	---	25.7	19.6	14.0
Tamarix aphylla	---	---	---	---	---	---	0.2	2.2	3.3
Tamarix dioica	---	---	---	---	---	---	3.4	15.2	26.4

R.D. = Relative density, R.F. = Relative frequency, R.C. = Relative cover

Table 6: Ecological studies of natural vegetation recorded at the newly demarcated area (site 4)

	Interdunal area at the western side with 2m high dunes (Sandy/ sandy loam)			Sandy dunes to 5m high at the wester side (Loose sand dunes)			Interdunal area at the eastern side with few saline patches (Sandy/sandy clay)		
Plant species	R.D.	R.F.	R.C.	R.D.	R.F.	R.C.	R.D.	R.F.	R.C.
Acacia jacquemontii	3.3	20.0	45.2	0.6	2.8	2.7	5.6	9.1	17.1
Aerva javanica	0.9	4.4	0.5	2.4	2.8	1.1	0.9	2.3	0.2
Aristida adscensionis	89.1	22.2	30.5	---	---	---	3.7	4.5	0.6
Calligonum polygonoides	3.1	17.8	20.2	9.6	22.2	29.4	18.7	15.9	35.4
Calotropis procera	---	---	---	0.6	2.8	2.7	---	---	---
Capparis decidua	---	---	---	1.2	2.8	5.4	2.8	4.5	9.3
Cenchrus pennisetiformis	0.7	4.4	0.3	6.0	2.8	1.1	0.9	2.3	0.2
Crotalaria burhia	0.2	2.2	0.1	---	---	---	---	---	---
Cymbopogon jwarancusa	0.2	2.2	0.1	38.6	25.0	14.7	---	---	---
Dipterygium glaucum	0.5	4.4	0.3	---	---	---	19.6	13.6	1.3
Haloxylon recurvum	0.5	2.2	0.1	3.6	2.8	2.7	29.9	20.5	16.4
Heliotropium crispum	0.2	2.2	0.1	---	---	---	---	---	---
Lasiurus scindicus	0.2	2.2	0.1	31.9	22.2	14.2	---	---	---
Leptadenia pyrotechnica	0.7	8.9	2.0	3.0	2.8	1.1	11.2	20.5	18.2
Ochthochloa compressa	0.2	2.2	0.1	---	---	---	---	---	---
Prosopis cineraria	---	---	---	1.8	8.3	11.2	---	---	---
Salsola baryosma	---	---	---	---	---	---	6.5	6.8	1.3
Stipagrostis plumosa	0.3	4.4	0.3	---	---	---	---	---	---
Tamarix aphylla	---	---	---	0.6	2.8	13.6	---	---	---

R.D. = Relative density, R.F. = Relative frequency, R.C. = Relative cover



Abutilon indicum* (Ai), *Acacia jacquemontii* (Aj), *A. nilotica* (An), *Achyranthes aspera* (Aa), *Aeluropus lagopoides* (Al), *Aerva javanica* (Ajv), *Alhagi maurorum* (Am), *Amaranthes viridis* (Av), *Aristida adscensionis* (Aad), *A. hystricula* (Ah), *A. mutabilis* (Amu), *Calligonum polygonoides* (Cp), *Calotropis procera* (Cpr), *Capparis decidua* (Cd), *Cenchrus pennisetiformis* (Cpn), *Conyza ambigua* (Ca), *Cressa cretica* (Cc), *Crotalaria burhia* (Cb), *Cymbopogon jwarancusa* (Cj), *Cynodon dactylon* (Cda), *Cyperus rotundus* (Cr), *Dalbergia sissoo* (Ds), *Datura fastuosa* (Df), *Desmostachya bipinnata* (Dp), *Dichanthium annulatum* (Da), *Diclyptera bupleuroides* (Dbu), *Dipterygium glaucum* (Dg), *Eclipta alba* (Ea), *Eucalyptus camaldulensis* (Ec), *Euphorbia granulata* (Eg), *E. hirta* (Eh), *E. prostrata* (Ep), *Fagonia indica* (Fi), *Haloxylon recurvum* (Hr), *H. salicornicum* (Hs), *Heliotropium crispum* (Hc), *Imperata cylindrica* (Ic), *Lappula spinocarpos* (Ls), *Lasiurus scindicus* (Lsc), *Leptadenia pyrotechnica* (Lp), *Ochthochloa compressa* (Oc), *Panicum antidotale* (Pa), *P. turgidum* (Pt), *Prosopis cineraria* (Pc), *P. glandulosa* (Pg), *Saccharum bengalense* (Sb), *S. spontaneum* (Ss), *Salsola baryosma* (Sba), *Salvadora oleoides* (So), *Sporobolus ioclados* (Si), *Stipagrostis plumosa* (Sp), *Suaeda fruticosa* (Sf), *Tamarix aphylla* (Ta), *T. dioica* (Td), *Withania somnifera* (Ws)

Fig. 2: Importance value of plant species recorded in Lal Suhanra National Park

scindicus dominated the sandy habitat and *Aristida adscensionis* confined to sandy loam habitat.

Several grasses are of extreme value as fodder as well as hay production. Important of them are *Cenchrus pennisetiformis, Cynodon dactylon, Dichanthium annulatum, Lasiurus scindicus, Ochthochloa compressa, Panicum turgidum* and *Stipagrostis plumosa* (Cope, 1982; Chaudhary, 1989). Most of them are capable to withstand long periods of drought (Whyte *et al.*, 1959).

Many plant species possess high medicinal values. Leaf juice of *Calotropis procera* is used as purgative and for treatment against guinea worms. Root bark is used to treat leprosy and dysentery; also used as diaphoretic, expectorant and emetic. Plant parts of *Withania somnifera* have sedative effects, fruits are diuretic and roots are used in debility and rheumatism. Leaves are used for general weakness and rheumatism. Decoction of roots is used to treat diseases of the rectum. Roots are diuretic and promote urination. Roots and leaves possess antibiotic and antibacterial activities. (Nasir and Rafiq, 1995).

Achyranthes aspera leaves reduce the pains of scorpion stings. Plant is used in cough and decoction is given in renal dropsy and bronchial infection. Decoction of leaves of *Eclipta alba* is used to encourage the growth of hair on new-born children. *Cressa cretica* plant is used as tonic. *Euphorbia hirta* plant is used as sedative and to assist the breathing of asthmatics; also useful in bronchial affections and cough and in removing worms in children and in bowel complaints. Leaf extract of *Abutilon indicum* is used as disinfectant on wounds etc. Leaves and seeds are used as demulcent and laxative. Bark and roots are diuretic. *Cymbopogon jwarancusa* is used to treat stomach complaints, cholera, coughs, rheumatism, gout and fever. Leaves of *Datura fastuosa* are smoked as a cure for asthma (Usher, 1974).

Young shoots and leaves of *Capparis decidua* are used as plasters for boils and swellings. Powdered plant parts are useful in toothache. Bark is useful for cough and asthma. Root bark is given in intermittent fevers. *Vallisneria spiralis* is used as stomachic. Rhizomes of *Nelumbo nucifera* are given in dysentery and diarrhea. *Alhagi maurorum* is used as laxative, diuretic and expectorant. Leaf oil is sued for curing rheumatism. Flower buds of *Calligonum polygonoides* are effective in treating sun-stroke. Leaves of *Salvadora oleoides* are used to reduce cough. Alcoholic extracts of leaves of *Phyla nodiflora* have antibacterial activities (Singh *et al.*, 1983).

In spite of their huge economic importance, the cultivated trees have some medicinal properties too. *Eucalyptus* oil is extensively used in aroma therapy medicines because it is suitable for cold sores, cold, cough, diabetes, headache, influenza, respiratory infection and sore throat. Gum of *Acacia nilotica* is used for its demulcent effect, and in preparing pills like pastilles and lozenges (Bruce and Meeus, 2000; Singh *et al.*, 1983).

Lal Suhanra National Park is an excellent habitat for a number of wildlife species containing a large number of valuable plants. Several grasses are of high fodder value. *Dichanthium annulatum, Cenchrus pennisetiformis, Cynodon dactylon* and *Ochthochloa compressa* are considered to be good fodder grasses, while *Panicum antidotale* and *Aristida adscensionis* may cause some problems to livestock, especially at maturity (Khan, 1957). Nutritive value of some grasses was considered to be very high (Malik and Khan, 1967), especially those of *Cymbopogon jwarancusa, Cenchrus pennisetiformis, Cynodon dactylon* and *Panicum antidotale*, but *Cymbopogon jwarancusa* is palatable only at early growth stages. At maturity it repels the animals due to unpleasant smell.

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