STRUCTURE & COMPOSITION OF BARASINGHA HABITAT IN HASTINAPUR WILDLIFE SANCTUARY



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Sponsored & Funded by Conservation Force Inc, USA

WILDLIFE SOCIETY OF INDIA Department of Wildlife Sciences AMU, Aligarh, India Technical Report No. 14

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Citation: J. A. Khan, Afifullah Khan & A. A. Khan (2003). Structure and composition of barasingha habitat in Hastinapur Wildlife Sanctuary. Technical Report No. 14, Wildlife Society of India, AMU, Aligarh. 57 Pp.

Cover Photograph: Satish Kumar

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1. INTRODUCTION

Schaller (1967) documented the status of swamp deer Cervus duvauceli duvauceli in Terai grasslands of Northern India. Holloway (1973) reviewed the status of barasingha and found that it survived only in three localities by 1970's. The barasingha populations in the three localities reported by Holloway (1973) continued to decline. For example Ravi Sankaran (1990) reported that Satiana grassland in the Dudhwa Tiger Reserve had 1200 barasingha in the early 1970's. This number declined to 300 by 1990's. It is believed that not more than 1500 individuals of this sub species currently survive in wild. Khan and Khan (1999) found another population of barasingha in Hastinapur Wildlife Sanctuary. This population is scattered over a large area in Hastinapur Wildlife Sanctuary and is under tremendous anthropogenic pressure due to dependence of large number of local people. The Wildlife Society of India has initiated a conservation project titled "Strengthening conservation and management of barasingha population in Hastinapur Wildlife Sanctuary" with financial support from the Conservation Force Inc, USA. The project aims to document conservation problems faced by barasingha population in Hastinapur Wildlife Sanctuary and implement actions which can improve prospects of conservation of barasingha in Hastinapur Sanctuary. This population has tremendous conservation value as it is geographically at least 500-600 km away from the Dudhwa-Kishanpur-Katarniaghat Conservation Units, which is the last stronghold of this sub species in India. This report presents the preliminary results of documentation of plant diversity of barasingha habitat in Hastinapur Wildlife Sanctuary. We wish to place on record our deep

sense of gratitude to the Conservation Force Inc, USA for funding our present work in Hastinapur Wildlife Sanctuary. In particular Mr. John Jackson III and Dr. William McShea are thanked for their keen interest and generous help and support in this endeavor.

2. STUDY AREA

The Hastinapur Wildlife Sanctuary (Fig. 1) is situated between 28⁰ 46' and 29⁰ 35'N latitude and 77⁰ 30' and 78⁰ 30' E longitude in Uttar Pradesh state of India. It encompasses an area of 2073 km² along the banks of Ganges in five district of Uttar Pradesh, namely Muzaffarnagar, Bijnor, Meerut, Ghaziabad and Moradabad. The altitude of the area ranges between 130 and 150 m above the sea level. The sanctuary is the sole protected area in India conserving the endangered Gangetic grassland biome. The vegetation of the sanctuary can be classified into three main types: The tall wet grasslands, in low lying areas, remain inundated for most part of the year; short wet grasslands, remain dry from mid-winters till the onset of monsoon; and dry scrub grasslands on raised grounds amidst the Ganga and on highland also called as 'Khola'. Tall wet grasslands are dominated by grass species like Saccharum spotaneum, Eriathus revennae and *Phragmites* sp. The dicot species growing with *Saccharum* are Nymphoides cristatum and Vicoa vestila. Major grass species growing in short wet grasslands are Imperata cylindrica, Paspalidium and Typha while their dicot associates are Bacopa monieri, Rananculus cantonensis and polygonum lanigerum. Major species growing in dry scrub grasslands are Tamarix sp., Veteveria ziznoides and Dichanthium annulatum while commonly occurring tree species are Accacia spp., Dalbergia sissoo and



Figure 1: Map of Hastinapur Wildlife Sanctuary

Bombax cieba. At few places on the highlands, the forest department has raised *Eucalyptus, Acaia, Syzygium* and *Dalbergia* plantations as part of Social Forestry Scheme. Of the total Sanctuary area, tall wet grasslands occupy 6%, short wet grasslands occupy 4%. Dry scrub grasslands and plantation occupy 5% and 2% respectively. The rest of the Sanctuary in under cultivations and township and human disturbance is considerable through out the Sanctuary. Climatically, the study area has three distinct seasons namely Winter (October to mid-March), summer (mid-March to mid-June) and monsoon (mid-June to September). May and June are hottest months when temperature reaches about 45°C, December and January are coldest and temperature can reach near 0°C. the annual precipitation is about 1200 mm.

3. METHODOLOGY

3.1 DATA COLLECTION

A general vegetation survey was carried out in study area and plants were collected, which were dried and later transferred on to herbarium sheets. Plants with inflorescence and fruits were mostly identified in the field and species that could not be identified were given code names. These species were later identified. The study area was divided into three habitats viz. Scrubland, Short dry grasslands and Tall wet grasslands. Stratified Random Sampling method was used to collect quantitative data on vegetation parameters following Mueller-Dombois & Ellenberg (1974). Two transect each of one km length were laid in respective habitats. Along a transect, vegetation sampling was carried out at a regular interval of 50 m. at each sampling point, tree species were counted in 10 m radius circular

plot while shrubs and herbs were counted in 2 m radius circular plot. Grass species were counted in a four 0.5 x 0.5 m quadrat. Each grass clump was considered as one individual. Data on disturbance factors such as number of trees and shrubs cut, grazing, cattle dung and fire were recorded on ordinal scale of 0 to 3 where 0 represented, for example, no grazing and 3 represented sever grazing.

3.2 DATA ANALYSIS

Density of each species in every sampling plot was calculated by dividing the total number of individuals of a particular species by the area of the circular plot (Mueller-Dombois & Ellenberg, 1974). The individual density value for each species in each plot were added together to calculate mean density value for each species and its 90% confidence limit. The diversity of different layers was calculated by Shannon-Weiner Diversity Index (H') using the formula:

 $H' = \sum pi x \log pi$

Where pi is the proportion of ith species in the sample.

The species richness was calculated by the Margalef's Richness Index *(RI)* using the formula:

 $RI = S-1/\log n$

Where, S is the number species in the sample, n is the number of individuals. The Eveness Index *(EI)* was calculated using Simpson Eveness Index as:

 $EI = D/D \max$

Where D is diversity index and D max is the maximum possible value for diversity index. A hierarchical cluster analysis was performed using Nearest

neighbor classification strategy by computer program SPSS (Vr 6.1) for classification of herbs and grass communities.

4. RESULTS

4.1 GENERAL VEGETATION SURVEY

A total of 189 plant species were collected of which 186 were identified while three species remained to be identified. The identified species belonged to 58 families. A list of plant species identified during the surveys in given in Appendix-I. The augmentation of plant list will continue till the end of the project.

4.2 PLANT SPECIES COMPOSITION IN SCRUBLAND

A total 43 species of plants were recorded in this vegetation type of which there were five species of trees, four species of shrubs, 26 species of herbs and eight species of grasses. The overall mean density of tree species was 16/hectare. However, the densities of individual species ranged between less than one tree/ha to 49 trees/ha. *Fernandoa adenophylla* had the highest density (49 trees/ha). It was followed by *Acacia catechu* (30 tree/ha), *Dalbergia sissoo* (10 trees/ha) and *Nyctanthes arbortristis* (5 trees/ha). The lowest density was recorded in case of *Melia azedarach*, which was 0.8/ha. Table 1 summarizes the mean densities, standard deviation, frequency and relative frequency of various tree species recorded in scrubland.

Among the shrub species, the density of *Lantana camara* was recorded highest (20 plants/100m²). It was followed by *Helicteres isora* (9.55 plants/100 m²) and *Peristrophe paniculata* (7.52 plants/100 m²). The density of *Ziziphus oenoplia* was lowest (2.59 plants/100 m²). The overall

density of shrub species was 9.95±7.6 plants/100 m². Table 2 summarizes the mean densities, standard deviation, frequency and relative frequencies of various shrub species recorded in scrubland.

The overall mean density of herb species in scrubland was calculated as 30.03 ± 20.57 plants/100 m²). *Rorippa indica* had the highest density (185.11 plants/100 m²) while *Oxalis corniculata* had the lowest density (0.6 herbs/100 m²). The density of other herb species frequently occurring in this vegetation type, such as *Sida acuta, Antirrhinum orontium* and *Parthenium hysterophorus* was 175.73, 95.54 and 91.96 herbs/100 m² respectively. The densities, standard deviation, relative densities, frequencies and relative frequencies of herb species occurring in scrubland are given in Table 3.

Mean densities of grass species ranged between 9.98 clumps/m² and 0.13 clumps/m². The highest density was recorded for *Cynodon dactylon* (6.96 clumps/m²). It was followed by *Desmostachya bipinnata* (6.93 clumps/m²), *Eragrostis tenella* (2.8 clumps/m²) and *Heteropogon contortus* (1.7 clumps/m²). Other grasses species occurring in low densities were *Perotis indica* (0.95 clumps/m²), *Dactyloctenium aegyptium* (0.35 clumps/m²), *Cenchrus ciliaris* (0.13 clumps/m2) and *Phragmites karka* (0.05 clups/m2). A list of grass species along with densities, frequencies, relative densities and frequencies and standard deviation in Table 4.

4.3 PLANT SPECIES COMPOSITION IN SHORT DRY GRASSLAND

In Short grasslands, six species of grasses, four species of shrubs, 27 species of herbs and three species of trees were recorded. The overall mean density of grass species was 2.67 ± 1.83 clumps/m². The density of

Cynodon dactylon was highest (5.98 clumps/m²). The densities of *Desmostachya bininnata*, *Perotis indica*, *Cenchrus cilliaris* and *Eragrostis tenella* were 4.85, 2.43, 1.63 and 1.13 clupms/m² (Table 5).

Out of the total twenty-seven herb species recorded *Rorippa indica* had the highest density (77.83 plants/100m²). It was followed by *Antorrhinum orontium* (65.29 plants/100m²), *Sida acuta* (54.737 plants /m²) *Boerhavia diffusa* (31.25 herbs/m²), *Barlenia cristata* (32.64/100m²), *Gnaphalium pensylvanicum* (29.66plants/100m²), *Achyranthes aspera* (16.32 plants/ 100m²), *Aerva javanica* (12.34 plants/100m²) and *Parthenium hysterophorus* (10.95 plants/m²). Table 6 presents the densities of herb species as recorded in short dry grasslands.

Among the shrub species, *Aretmisia scoparia* was the dominant shrub in this vegetation type with a mean density of 202.03 plants/ $100m^2$. Other three species of shrub had very low densities. *Lantana camara* had a density of 4.18 plants/ $100m^2$, while the densities of *Peristrophe paniculata* and *Helicteres isora* were 3.18 and 3.38 plants / $100m^2$ respectively (Table 7). The overall mean density of shrubs was 53.19 ± 97.24 plants / $100m^2$.

The short dry grassland are not the climax type but they are edaphic type. High grazing pressure, repeated fire and extraction of plants, cutting of trees etc are some of the factors responsible for arresting the process of natural succession. These grasslands therefore, have shrub as well as tree layers. However, the density of trees is very low. The overall mean density of trees was recorded as 2.44±1.96 tree/ha. *Prosopis juliflora* had maximum mean density of 12.74 tree/ha. While *Albizia lebbeck*, *Femandoa*

adenophylla and *Dalbergia sissoo* had mean densities of 12.74, 3.98 and 3.18 trees /ha respectively (Table 8).

4.4 SPECIES COMPOSITION OF TALL WET GRASSLAND

Tall Wet Grasslands are characterized by high density of grass species and low occurence of shrubs. A total of 22 species of herbs, 5 species of grasses and only two species of shrubs were recorded in vegetation type. Overall mean densities of shrub species was 0.6 ± 0.392 plants/100m² of which *Lpomoea camea, spp. fistulosa* and *Tamarix dioica* had a mean density of 0.8 and 0.4 plants 100 m².(Table 9).

Of the twenty-two species of herbs, the maximum mean density was recorded in case of *Trifolium tomentosum* (370.62 plants/m²) followed by *Vicia sativa* and *Medicago lupulina* each having a density of 246.46 and 245.81 herbs /m² respectively. The lowest density was of *Gnaphalium pensylvanicum* (0.4 plants/100m²). The overall mean density of herb species was calculated as 58.105 ± 42.79 plants/100 m². The mean density of each shrub species recorded in Tall Wet Grasslands is given in Table 10.

The overall mean density of grasses was 8.83 ± 7.91 clumps/m² which is much higher as compared to dry short grasslands. Among the five species of grasses recorded in this vegetation type *Phragmites karka* is the dominant species with a mean density of 28.53 clumps/m². Other species, such as *Carex fedia* (Cyperaceae) had a mean density of 8.35 plants/m² and *Echinochola frumentacea* (1.43 clumps/m²) Table 11

4.5 SPECIES DIVERSITY, RICHNESS AND EVENNESS OF DIFFERENT HABITATS

A total of six tree species were recorded in Scrubland while only three species were recorded in Dry grassland. There was no occurrence of tree species in Tall wet grassland. Scrubland was found to be more diverse with a diversity index of 0.52 while Dry grassland was less diverse with respect to tree species having a diversity index equal to 0.39. Richness was maximum in Scrubland (1.039) as compared to Dry grassland (0.62), however, in contrast the evenness was found to be maximum in Dry grassland with a value equal to 0.78 as compared to Scrubland where evenness was calculated as 0.76. An equal number of four shrub species were recorded in Scrubland as well as in Dry grassland while two shrub species in Tall grassland (Table 12).

Scrubland was more diverse in terms of shrub species (0.50) while Dry grassland was less diverse with a value of 0.07. Diversity for Tall wet grassland species was calculated as 0.27. Scrubland had a maximum richness value (0.56) followed by Tall wet grasslands (0.40). Tall wet grasslands showed more evenness (0.889) in comparison to Scrubland (0.84) while Dry grassland recorded the minimum value (0.08) Table 13.

Dry grassland were having twenty seven species of herbs, followed by scrubland having twenty five species and tall wet grassland was having twenty two species of herbs. Diversity (1.41) and richness (3.35) was highest in Dry grasslands while minimum in tall wet grassland. Evenness was high (0.93) in Dry grassland followed by scrubland (0.88) while low in tall wet grassland (0.85) Table 14.

Eight grass species were recorded in Scrubland followed by six and five in Dry grassland and Tall wet grassland respectively. Diversity (0.64) and richness (1.04) of grass species were maximum in Scrubland while minimum in Tall wet grassland. Evenness was high (0.87) in Dry grassland followed by Scrubland (0.82) while low in Tall wet grassland (Table 15).

4.6 CLASSIFICATION OF HERBS AND GRASS SPECIES

Table 17 presents the classification of herb species using complete linkage cluster analysis. A total of four clusters are identified. The first cluster has 16 species which included, species such as *lxes, Soliva anthemifolia*, Bacopa monneiri, Oxalis corniculata, Anisomeles indica and Emilia sonchifolia etc. he second cluster comprised of 20 herb species such as Portulaca pilosa, Evolvulus alsinoides, Anisomeles indica, Tephrosia purpurea etc. The third cluster comprised of 6 species, which included Medicago lupulina, Phyla nodiflora, Ranunculus cantoniensis, Trifolium, Boerhavia etc. The fourth cluster included a total of seven species such as Antirrhinum orontium and Rorippa indica, Achyranthes aspera. These three species were found to be the associated species. Table 18 provides the classification of grass species using complete linkage cluster analysis. It included three groups, the first group comprises of six grass species which included Dactyloctenium, Chloris, Echinochola, Heteropogon, Eragrostis and *Perotis*. The second cluster comprised of *Carex*, *Phragmites*, and one unidentified species. The third cluster included two grass species e.g. Cynodon and Desmostachya.

4.7 VARIOUS BIOTIC PRESSURES ON DIFFERENT HABITATS

The number of tree cut is high in scrubland and is also affected by a high percentage of fire. However, there is low grazing pressure. In dry grassland the number of scrub cut is less but there is moderate percentage of fine and a high grazing pressure, while in tall wet grassland number of shrub cut is highest and also pressure is high. However it is less affected by fire (Table 16).

S.No	Species	M.D.	S.D.	R.D.	Freq.	R.F
1	Dalbergia sissoo	10.35	29.20	0.106	0.17	0.143
2	Acacia catechu	30.25	36.02	0.309	0.52	0.429
3	Fernandoa adenophylla	49.36	85.53	0.504	0.42	0.347
4	Melia azedarach	0.80	0.008	0.008	0.02	0.020
5	Nyctanthes arbor-tristis	5.57	0.057	0.057	0.02	0.020

Table 1: Summarizes the mean density of different tree species in scrubland.

S.No	Species	M.D.	S.D.	R.D.	Freq.	R.F
1	Helicteres isora	9.55	20.49	0.240	0.275	0.229
2	Lantana camara	20.90	23.96	0.525	0.575	0.479
3	Ziziphus oenoplia	23.96	7.52	0.065	0.150	0.125
4	Peristrophe paniculata	7.52	18.43	0.170	0.200	0.167

 Table 2: Summarizes the density of different scrub species in scrubland.

S	Species	M.D.	S.D.	R.D.	Freq.	R.F
No						
1	Boerhavia diffusa	40.01	45.31	0.053	0.675	0.116
2	Unidentified 1	0.60	3.78	0.001	0.025	0.004
3	Antrirrhinum orotium	95.54	214.13	0.127	0.55	0.094
4	Chenopodium album	7.76	34.56	0.010	0.05	0.008
5	Cannabis sativa	9.16	33.37	0.012	0.1	0.017
6	Parthenium hysterophorus	91.96	132.37	0.122	0.725	0.124
7	Unidentified 2	6.17	23.12	0.008	0.075	0.013
8	Urena lobata	4.38	16.42	0.006	0.1	0.017
9	Phyllanthus urenaria	25.28	56.36	0.034	0.275	0.124
10	Aerva sanguinolenta	8.16	17.34	0.011	0.325	0.013
11	Anisomeles indica	1.59	6.55	0.002	0.1	0.017
12	Sida cordiforlia	50.76	71.03	0.067	0.575	0.047
13	Lannaea procumbens	1.39	4.37	0.002	0.125	0.056
14	Rorippa indica	185.11	297.35	0.246	0.425	0.017
15	Achyranthes aspera	20.30	30.91	0.027	0.5	0.099
16	Emilia sonchifolia	3.58	13.36	0.005	0.125	0.021
17	Crotalaria medicagenia	1.59	10.07	0.002	0.025	0.007
18	Tephrosia purpurea	2.99	11.21	0.004	0.1	0.086
19	Tridax procumbens	3.58	15.19	0.005	0.075	0.013
20	Sida acuta	176.73	339.76	0.235	0.475	0.013
21	Barleria cristata	5.77	17.76	0.008	0.125	0.021
22	Tribulus terrestris	1.40	6.72	0.002	0.05	0.008
23	Evolvulus alsinoides	2.39	9.23	0.003	0.075	0.013
24	Trichodesma indica	4.18	12.49	0.005	0.125	0.021
25	Oxalis corniculat	0.60	3.76	0.001	0.025	0.025
26	Cassia occidentalis	1.59	7.03	0.01	0.05	0.04

Table 3: Summarizes the density of different herb species in scrubland.

M.D. = Mean density, S.D. = Standard deviation, R.D. = Relative density, Freq.= Frequency, R.F. = Relative frequency

S.	Species	M.D.	S.D.	R.D.	Freq.	R.F
No						
1	Cynodon dactylon	6.98	8.70	0.351	0.625	0.25
2	Desmostachya bipinnata	6.93	5.31	0.348	0.95	0.38
3	Heteropogon contortus	1.7	4.65	0.085	0.25	0.1
4	Pharagmited karka	0.05	0.32	0.002	0.025	0.01
5	Eragrostis tenella	2.8	7.19	0.141	0.275	11
6	Dactyloctenium aegyptium	0.35	1.23	0.176	0.125	0.05
7	Perotis indica	0.95	2.23	0.048	0.225	0.09
8	Cenchrus ciliaris	0.13	0.79	0.006	0.025	0.01

Table 4: Summarizes the mean density of different grass species in scrub land

S. No	Species	M.D.	S.D.	R.D.	Freq.	R.F
1	Desmostachya bipinnata	4.85	3.08	0.302	0.975	0.361
2	Cenchrus ciliaris	1.63	3.18	0.102	0.35	0.361
3	Cynodon dactylon	5.98	5.25	0.373	0.775	0.287
4	Eragrostis tenella	1.13	2.49	0.07	0.225	0.083
5	Perotis indica	2.43	4.84	0.151	0.35	0.13
6	Heteropogon contortus	0.03	0.16	0.002	0.025	0.009

Table 5: Summarizes the mean density of different grass species in short

 dry grassland

S. No	Species	M.D.	S.D.	R.D.	Freq.	R.F
1	Boerhavia diffusa	31.25	33.89	0.07	0.65	0.091
2	Rorippa indica	77.83	210.85	0.174	0.275	0.038
3	Antirrhinum orontium	65.29	149.19	0.146	0.45	0.063
4	Evolvulus alsinoides	8.76	20.93	0.02	0.3	0.042
5	Amebia hispidissima	9.35	23.57	0.021	0.275	0.038
6	Achyranthes aspera	16.32	30.54	0.036	0.45	0.063
7	Sida cordifolia	50.95	59.57	0.114	0.775	0.108
8	Pathenium hyterophorus	10.95	29.66	0.024	0.175	0.024
9	Trichodesma indica	1.39	5.37	0.003	0.1	0.014
10	Tephrosia purpurea	5.77	15.08	0.013	0.25	0.035
11	Gnaphalium pensylvanicum	29.66	77.44	0.066	0.275	0.038
12	Sida acuta	54.74	159.29	0.122	0.225	0.031
13	Anisomeles indica	0.60	2.79	0.001	0.05	0.007
14	Launea procumbens	4.78	16.11	0.011	0.45	0.063
15	Portulaca procumbens	3.38	8.99	0.008	0.125	0.017
16	Barleria cristata	32.64	75.55	0.073	0.4	0.056
17	Polycarpaea corymbosa	2.59	11.87	0.006	0.05	0.07
18	Tridax procumbensa	3.38	8.99	0.008	0.175	0.024
19	Oxalis corniculata	1.79	11.33	0.004	0.025	0.003
20	Atylosia scarabaeoides	5.97	20.22	0.013	0.45	0.063
21	Urena lobata	5.37	10.57	0.012	0.225	0.031
22	Crotalaria medicaginea	0.40	2.52	0.001	0.025	0.003
23	Unidentified 1	1.79	6.62	0.004	0.075	0.01
24	Emilia sonchifolia	2.19	6.98	0.005	0.45	0.063
25	Ocimum basilicum	2.99	13.45	0.007	0.05	0.07
26	Aerva javanica	12.34	25.56	0.028	0.275	0.038
27	Phyllanthus urinaria	5.57	16.14	0.012	0.125	0.017

Table 6: Summarizes the mean density of different herb species in short

 dry grassland

S. No	Species	M.D.	S.D.	R.D.	Freq.	R.F
1	Artemisa scoparia	202.03	319.46	0.949	0.9	0.581
2	Helicteres isora	3.38	7.62	0.016	0.225	0.145
3	Peristrophe paniculata	3.18	8.02	0.015	0.175	0.113
4	Lantana camara	4.18	8.64	0.020	0.25	0.161

Table 7: Summarizes the mean density of different shrub species in short

 dry grassland

S. No	Species	M.D.	S.D.	R.D.	Freq.	R.F
1	Desmostachya bipinnata	4.85	3.08	0.302	0.975	0.361
2	Cenchrus ciliaris	1.63	3.18	0.102	0.35	0.361
3	Cynodon dactylon	5.98	5.25	0.373	0.775	0.287
4	Eragrostis tenella	1.13	2.49	0.07	0.225	0.083
5	Perotis indica	2.43	4.84	0.151	0.35	0.13
6	Heteropogon contortus	0.03	0.16	0.002	0.025	0.009

Table 8: Summarizes the mean density of different grass species in short

 dry grassland

S. No	Species	M.D.	S.D.	R.D.	Freq.	R.F
1	Ipomoea fistulosa	0.8	3.02	0.667	0.075	0.6
2	Tamarix diolica	0.4	1.76	0.333	0.05	0.4

Table 9: Summarizes the mean density of different shrub species in tall wet grassland

S. No	Species	M.D.	S.D.	R.D.	Freq.	R.F
1	Vicia sativa	246.46	210.69	0.19260	0.875	0.164
2	Trifolium tomentosum	370.62	1011.2	0.2899	0.65	0.122
3	Medicago lupulina	245.81	278.36	0.1921	0.875	0.127
4	Phyla nodiflora	146.9	168.17	0.1148	0.6	0.113
5	Launaea procumbens	11.94	38.5	0.0093	0.175	0.033
6	Urena lobata	0.4	1.76	0.0003	0.05	0.009
7	Portulaca pilosa	13.93	34.2	0.0109	0.275	0.052
8	Unidentified 1	96.73	191.27	0.075	0.425	0.08
9	Centella asiatica	4.38	15.29	0.0034	0.1	0.019
10	Polygonum barbatum	13.53	29.47	0.0106	0.25	0.047
11	Ranunculus cantoniensis	54.14	91.73	0.0423	0.5	0.094
12	Cirsium arvense	23.29	81.84	0.0182	0.1	0.019
13	Ranunculus sceleratus	31.85	111.97	0.0249	0.2	0.038
14	Unidentified 2	0.8	5.03	0.0006	0.025	0.005
15	Ixeris polycephala	0.6	3.78	0.0005	0.025	0.005
16	Potamogeton nodosus	2.19	6.74	0.0017	0.125	0.023
17	Emilia sonchifolia	0.4	2.52	0.0003	0.025	0.005
18	Bacopa monneiri	10.35	48.49	0.0081	0.05	0.009
19	Gnaphalium luteoalbum	0.4	2.52	0.0003	0.025	0.005
20	Zeuxine strateumatica	2.00	5.91	0.0016	0.125	0.023
21	Unidentified 3	1.79	11.33	0.0014	0.025	0.005
22	Soliva anthemifolia	1.00	6.29	0.0008	0.025	0.005

Table 10: Summarizes the mean density of different herb species of tall wet grassland

S. No	Species	M.D.	S.D.	R.D.	Freq.	R.F
1	Unidentified 1	5.05	3.23	0.114	1	0.328
2	Echinochloa frumentacea	1.43	3.64	0.032	0.2	0.066
3	Cynodon dactylon	0.88	1.24	0.02	0.5	0.164
4	Phragmited karka	28.53	31.31	0.645	0.775	0.254
5	Carex fedia (Cyperaceae)	8.35	10.81	0.189	0.575	0.189

Table 11: Summarizes the mean density of different grass species of tall wet grassland

Table 12: Summarizes the density, diversity, richness and evenness of tree species in different habitats

Habitat	Species	Density	Shanon	Margalef	Simpson's
		ha⁻¹	Index(H')	Index (R)	Index (E)
SGL	06	16.32± 15.57	0.528	1.039	0.763
DGL	03	6.63± 5.99	0.391	0.621	0.787
TWGL	0	0	0	0	0

SGL = Scrubland, DGL = Dry grassland, TWGL = Tall wet grassland

Habitat	Species	Density	Shanon	Margalef	Simpson's
		ha ⁻¹	Index(H')	Index (R)	Index (E)
SGL	4	9.95 ± 7.682	0.504	0.566	0.845
DGL	4	53.19 ± 97.24	0.079	0.406	0.086
TWGL	2	0.6 ± 0.392	0.276	0.558	0.889

Table 13: Summarizes the density, diversity, richness and evenness of scrub species in different habitats

SGL = Scrubland, DGL = Dry grassland, TWGL = Tall wet grassland

Habitat	Species	Density	Shanon	Margalef	Simpson's
		ha⁻¹	Index(H')	Index (R)	Index (E)
SGL	25	30.03 ± 20.57	0.962	2.91	0.88
DGL	27	16.594 ± 8.20	1.141	3.359	0.937
TWGL	22	105 ± 42.79	0.859	2.39	0.858

Table 14: Summarizes the density, diversity, richness and evenness of herb species in different habitats

SGL = Scrubland, DGL = Dry grassland, TWGL = Tall wet grassland

grasses in different habitats					
Habitat	Species	Density	Shanon	Margalef	Simpson's
		ha-1	Index(11)	Index (D)	Inday (E)

Table 15: Summarizes the density, diversity, richness and evenness of grasses in different habitats

Tubitut	Opeoles	Density	onanon	margaici	Omp30m3
		ha⁻¹	Index(H')	Index (R)	Index (E)
SGL	8	2.44 ± 1.96	0.645	1.048	0.829
DGL	6	2.675 ± 1.83	0.627	0.774	0.878
TWGL	5	8.83 ± 7.91	0.449	0.535	0.667

SGL = Scrubland, DGL = Dry grassland, T	WGL = Tall wet grassland
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Habitat	# of tree cut	# of shrub cut	% Fire	Grazing	# of cattle dung
SGL	21	27	32.35	Low	12
DGL	0	7	22.175	High	29
TWGL	0	32	0.5	High	61

 Table 16: Summarizes various biotic pressures of different habitats

SGL = Scrubland, DGL = Dry grassland, TWGL = Tall wet grassland

Cluster Number	Species
1	Ixeris polycephala, Soliva anthemifolia, Bacopa monnieri, Chenopodium album, Ocimum canum, Oxalis corniculata, Tribulus terrestris, Crotalaria medicaginea, Polycarpaea corymbosa, Crisium arvense, Centella asiatica, Zeuxine strateumatica, Unidentified 1,4 and 5.
2	Atylosia scarabaeoides, Anisomeles indica, Cannabis sativa, Ranumculus sceleratus, Polygonum barbatum, Portulaca pilosa, Evolvulus alsinoides, Amebia hispidissima, Tephrosia purpurea, Tridax procumbens, Trichodesma indica, Gnaphslium pensylvanicum, Launaea procumbens, Urena lobata, Barleria cristata, Aerva sp., Phyllanthus urinaria, Emilia sonchifolia, Vicia sativa, Unidentified 2
3	Medicago lupulina, Phyla nudiflora, Ranunculus cantoniensis, Trifolium tomentosum, Boerhavia diffusa, Unidentified 3
4	Sida cordifolia, Sida acuta, Parthrnium hysterophorus, Antirrhinum orontium, Rorippa indica, Achyranthes aspera

Table 17: Classification of herb species at Hastinapur Wildlife Sanctuary

Table 18: Classification of grass and sedge species at Hastinapur Wildlife

 Sanctuary

Cluster Number	Species
1	Dactyloctenium aegyptium, Chloris dolichostachya, Echinocloa sp., Heteropogon contortus, Eragrostis tenella, Perotis indica
2	Carex fedia, Phragmites karka, Unidentified 1
3	Cynodon dactylon, Desmostachya bipinnata

Appendix –I Checklist of plant species documented from Hastinapur Wildlife Sanctuary.

Acanthaceae

Adhatoda zeylanica Medic.

Barleria cristata L.

Blepharis maderaspatensis (L.) Heyne ex Roth

Justicia quinqueangularis Koenig ex Roxb.

Peristrophe paniculata (Forsk.) Brummitt

Rungia pectinata (L.) Nees

Amaranthaceae

Achyranthes aspera L.

Aerva javanica (burm.f.) Juss. Ex Schult.

Aerva sanguinolenta Kunth

Alternanthera sessilis (I.) R. Br. Ex DC.

Gfomphrena celosioides Mart.

Pupalia lappacea (L.) Juss.

Apiaceae (Umbelliferae nom. Alt.)

Centella asiatica (L.) Urban

Apocynaceae

Ichnocarpus frutescens (L.) R. Br.

Vallaris solanacea (Roth) Kuntze

Wrightia arborea (Dennst.) Mabb.

Asclepiadaceae

Calotropis procera (Alt.) Ait. F.

Oxystelma esculenta (L.f.) R. Br. Ex Schultes

Asteraceae (Compositae nom. Alt.)

Ageratum conyzoides L.

Artemisia scoparia Waldst. & Kit.

Bidens biternata (Lour.) Merr. & Sherrff ex Sherrf

Blumea sp.

Cirsium arvense (L.) Scop.

Eclipta alba (L.) Hassk.

Emilia sonchifolia (L.) DC.

Erigeron canadensis L.

Gnaphalium luteo – album L.

Gnaphalium pensylvanicum Willd.

Ixeris polycephala Cass.

Launaea procumbens (Roxb.) Ramayya & Rajagopal

Parthenium hysterophorus L.

Soliva anthemifolia (Juss.) R. Br. Ex Less.

Tagetes sp.

Tridax procumbes L.

Verbesina encelioides (Cav.) Benth. & Hook. F. ex A. Grey

Vernonia cinerea (L.) Less.

Xanthium strumarium L.

Brassicaceae

Rorrippa indica (L.) Hiern.

Bignoniaceae

Fernandoa adenophylla (Wall. Ex G. Don) Steenis

Boraginaceae

Arnebia hispidissima (Lehm.) DC. *Heliotropium strigosum* Willd. *Trichodesma indica* (L.) R. Br.

Cannabinaceae

Cannabis sativa L.

Capparaceae

Capparis deciduas (Forsk.) Edgew.

Capparis zeylanica L.

Caryophyllaceae

Arenaria serpyllifolia L.

Polycarpaea corymbosa (L.) Lam.

Caesalpiniaceae

Bauhinia variegata L.

Cassia occidentalias L.

Chenopodiaceae

Chenopodium album L.

Cleomaceae

Cleome viscisa L.

Commelinaceae

Commelina benghalebsis L.

Convolvulaceae

Evolvulus alsinoides (I.) L.

Ipomoea aquatica Forsk.

Ipomoea carnea Jacq. Sub sp. fistulosa (Mart. Ex Choisy) Austin

Ipomoea dasysperma

Ipomoea dichroa (Roem. & Schult.) Choisy

Ipomoea pes-tigridis L.

Merremia hederacea (Burm. F.) Hall. F.

Cucurbitaceae

Coccinia grandis (L.) J.O.Voigt Melothria maderaspatana (L.) Cogn. Solena heterophylla Lour. Trichosanthes cucumerina L.

Cyperaceae

Bulbostylis barbat (Rottb.) Clarke Cyperus niveus Retz. Fimbristylis miliacea (L.) Vahl

Ebenaceae

Diospyros cordifolia Roxb.

Ehretiaceae

Ehretia sp.

Euphorbiaceae

Croton bonplandianum Baill. Euphorbia hirta L. Kirganelia reticulata (Poir.) Baill. Phyllanthus urinaria L. Trewia nudiflora L.

Fabaceae

Abrus precatoris L.

Alysicarpus monilifer (L.) DC.

Atylosia scarabaeoides (L.) Benth. Ex Baker

Crotalaria medicaginea Lam.

Dalbergia sissoo Roxb.

Desmodium triflorun (L.) DC.

Indigofera linnaei Ali

Medicago lupulina L.

Rhynchosia capitata (Heyne ex Roth) DC

Sesbania sesban (L.) Merrill

Tephrosia purpurea (I.) Pers.

Trifolium tomentosum L.

Vicia sativa L.

Zornia gibbosa Span

Flacourtiaceae

Flacourtia indica (Burm. F.) Merrill

Lamiaceae

Anisomeles indica (L.) O. Kuntze Leucas cephalotes (Koen. Ex Roth) Spreng Nepeta hindostana (Roth) Haines Ocimum canum

Lythraceae

Ammannia baccifera L.

Rotala rotundifolia (Buch.- Ham. Ex Roxb.) Koehne

Malvaceae

Hibiscus lobatus (Murr.) O. Ktze

Kydia calycina Roxb.

Sida acuta Burm. F.

Sida cordifolia L.

Sida spinosa L.

Urena Lobata L.

Meliaceae

Melia azedarach .L

Menispermaceae

Cissampelos pareira L. var. hirsute (Buch. - Ham. Ex DC.) Forman

Cocculus hirsutus (L.) Diels

Menyanthaceae

Nymphoides hydrophylla (Lour.) Kuntze

Mimosaceae

Acacia catechu (L. f.) Willd.

Acacia farnesiana (L.) Wlld.

Acacia modesta Wall.

Albizia lebbeck (L.) Benth.

Mimosa himalayana Gamble

Prosopis juliflora (Swartz) DC.

Moraceae

Streblus asper Lour.

Nyctaginaceae

Boerhavia diffusa L.

Oleaceae

Ludwigia adscendens (L.) Schlecht.

Orchidaceae

Zeuxine strateumatica (L.) Schlecht.

Oxalidaceae

Oxalis corniculata L.

Pedaliaceae

Pedalium murex L.

Sesamum indicum L.

Plumbaginaceae

Plumbago zeylanica L.

Poaceae

Apluda mutica L.

Brachiaria ramsosa (L.) Stapf.

Cenchrus ciliaris L.

Chloris dolichostachya Lag.

Coix lacrymajobi L.

Cymbopogon jwarancusa (Jones) Schult.

Cynodon dactylon (L.) Pers

Dactyloctenium aegyptium (I.) Willd.

Dendrocalamus strictus (Roxb.) Nees

Desmostachya bipinnata (L.) Stapf.

Digitaria stricta Roth ex Roem. & Schult.

Echinochloa colona (L.) Link

Echinochloa frumentacea Link

Eleusine indica (L.) Gaertn.

Eragrostis tenella (L.) P. Beauv. Ex Roem. & Schult.

Eriochloa nubica (Steud.) Hack. & Stapf. ex

Hemarthria compressa (L. f.) R. Br.

Heteropogon contortus (L.) P. Beauv.

Hygroryza aristata (Retz.) Nees ex Wight & Arn.

Oplismenus burmannii (Retz.) P. Beauv.

Perotis indica (L.) O. Ktze Phragmites karka (Retz.) Trin. Ex Steud. Saccharum ravennae (L.) Murr. Saccharum spontanrum L. Setaria glauca (L.) P. Beauv. Setaria verticillata (L.) P. Beauv.

Polygonaceae

Antigonon leptopus Hook. & Arn. Polygonum barbatum L. Polygonum hydropiper L. Polygonum lapathifolium L.

Pontederiaceae

Eichhornia crassipes (Mart.) Solms.

Portulacaceae

Portulaca pilosa L.

Pontamogetonaceae

Potamogeton nodosus Poir.

Ranunculaceae

Ranunculas sceleratus L.

Ranunculus cantoniensis DC.

Rhamnaceae

Ziziphus nummularia (Burm. f.) Wight. & Arn.

Ziziphus oenoplia (L.) Miller

Ziziphus xylopyrus (Retz.) Willd.

Rubiaceae

Borreia articullaris (L.f.) F. N. Will.

Oldenlandia corymbosa L.

Rutaceae

Murraya koenigii (L.) Spreng.

Salicaceae

Salix tetrasperma Roxb.

Santalaceae

Santalum albnum L.

Scrophulariaceae

Antirrhinum orontium L.

Bacopa monnieri (L.) Wettst.

Bacopa procumbens (Mill.) Greenm.

Scoparia dulcis L.

Striga angustifolia (D. Don) Saldhana

Vderonica anagallis – aquatica L.

Solanaceae

Datura fastuosa L. Datura innoxia Mill. Nicotiana plumbaginifolia Viv. Solanum nigrum L. Withania somnifera (L.) Dunal

Sterculiaceae

Helicteres isora L. Melochia cor chorifolia L. Waltheria indica L.

Tamaricaceae

Tamarix dioica Roxb. Ex Roth

Typhaceae

Typha elephatina Roxb.

Verbenaceae

Clerodendrum phlomidis L. f. Lantana camara L. Lantana wightiana Wall. Ex Gamble Phyla nodiflora (L.) E.E.Greene

Vitaceae

Cayratia trifolia (L.) Domin

Zygophyllaceae

Tribulus terrestris L

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A: Leucas cephalotes



B: Peristrophe paniculata





A: Portulaca pilosa



B: Sida spinosa

Plate 6







A: Over grazing by livestock in HWLS degrades habitat and is a major health hazard to Barasingha.



B: Agriculture on encroached Gangetic Grasslands is a major cause of Barasingha habitat shrinkage leading to rise in Nilgai population

Plate 9



A: Sand extraction from the Ganges is major disturbance to Barasingha in HWLS



B: *Phragmites* extraction for paper industry in HWLS is main threat to Barasingha Habitat

Plate 10