ECOLOGY & CONSERVATION OF BARASINGHA (*Cervus duvauceli duvauceli*) IN NORTHERN INDIA

Funded by

Conservation Force Inc., USA

Implemented by

Wildlife Society of India
Department of Wildlife Sciences
A.M.U., Aligarh, India
Technical Report No.16

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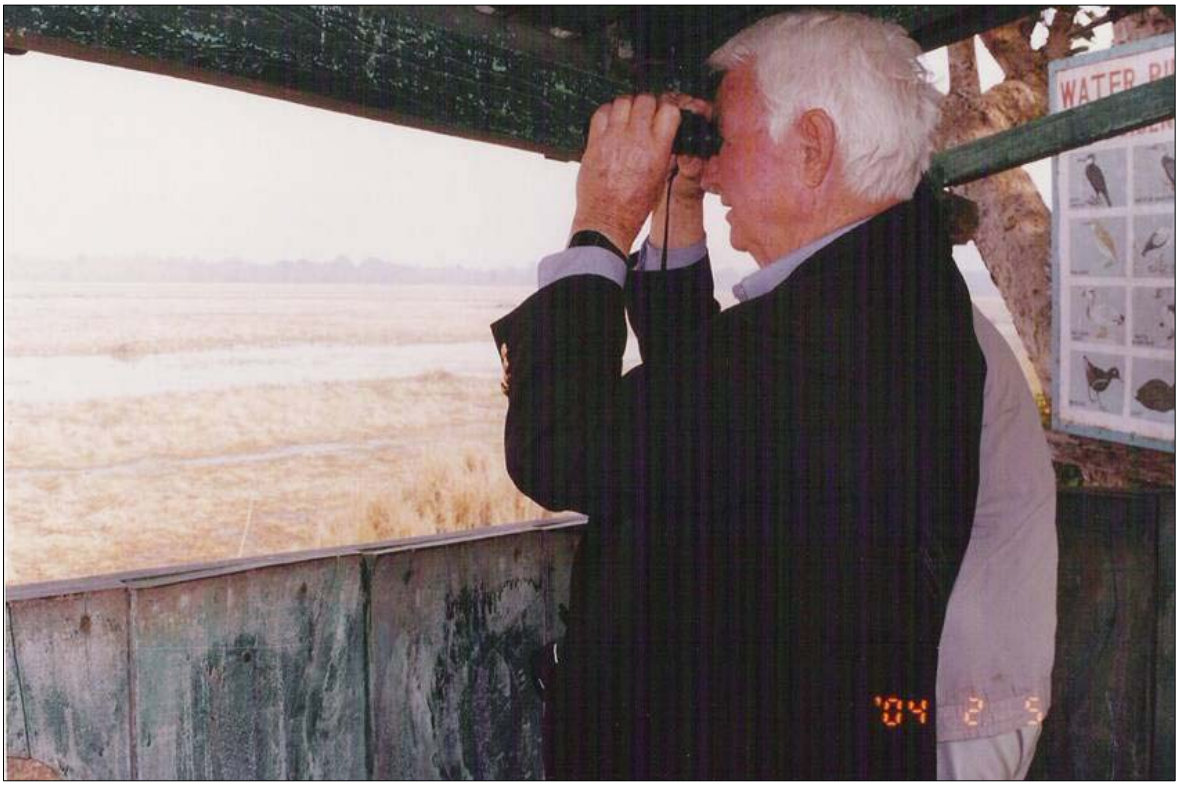
A REPORT ON THE VISIT OF PROFESSOR JAMES G. TEER

Emeritus Professor James G. Teer of the Texas A & M University visited the headquarter of the Wildlife Society of India from 2nd February 2004 to 7th February 2004. Professor Teer had discussions regarding the Barasingha Conservation Project being funded by the Conservation Force, Inc. USA. Professor James G. Teer, accompanied by Dr. Jamal A. Khan, Secretary, Wildlife Society of India, visited the Dudwa Tiger Reserve in Uttar Pradesh. The Dudwa Tiger Reserve covers an area of 614 km^2 and it has the largest population of the *Cervus duvauceli duvauceli*. Adjacent to the Dudwa Tiger Reserve is the Kishanpur Wildlife Sanctuary of approximately 227 km^2. The Dudwa-Kishanpur Protected Area Complex together holds the majority of the barasingha surviving in the wild. However the barasingha population in Dudwa-Kishanpur Complex faces a number of conservation problems which if addressed timely would help in long term conservation of this magnificent deer species. Professor Teer could visit both the areas and he held extensive discussion on the scope of covering Dudwa-Kishanpur Protected Area Complex under the CFI Barasingha Conservation Project. Professor Teer saw during his visit a number of large herds of Barasingha in Dudwa and Kishanpur complex. He reviewed the entire methodology being followed under the Barasingha Conservation Project and made very useful constructive suggestions and improvement. After his visit to Dudwa and Kishanpur Wildlife Sanctuary, Professor Teer delivered 16th Dr. Salim Ali Memorial Lecture at the Wildlife Society of India, Department of Wildlife Sciences, Aligarh Muslim University. The theme of Professor Teer lecture was ***"The Nilgai antelope and other large Indian Mammals in Texas: Problems with non native species***". The lecture was very well attended by the senior members of the Faculty of Life Sciences, Aligarh Muslim University. The visit of Professor Teer was his second visit to the Aligarh Muslim University since he first visited A.M.U. in 1986 for an International Conference on the role of universities in wildlife education and conservation.

Dr. Jamal A. Khan, Secretary, WSI showing pugmarks of tiger to Professor Teer in Dudwa Tiger Reserve and discussing grassland management issues.

Prof. Teer inspecting other grassland patches in Dudwa.

Barasingha habitat in Dudwa Tiger Reserve and Kishanpur Sanctuary.



Prof. Teer watching a barasingha herd from a watch tower in Dudwa and another grassland patch in Dudwa.

Prof. Teer delivering the 16th Dr. Salim Ali Memorial Lecture and a view of audience.

Dr. Jamal A. Khan, Secretary, Wildlife Society of India and Chairman, Department of Wildlife Sciences delivered the vote of thanks.

Prof. Teer with Prof. A. H. Musavi, Founder Chairman, Department of Wildlife Sciences and Founder President, Wildlife Society of India

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CHAPTER –1

INTRODUCTION

1.1 Rationale

Most threatened species of deer occur in isolated rural areas of developing countries where wildlife poaching and pressure on wildlife habitats, like grazing, cutting of grass and collection of fuel wood is frequently intense (Holloway 1975). This is unfortunate; that many of these species are on the verge of extinction and a detailed knowledge of their ecology is required for long-term conservation measures (Martin 1977). The rapid decline of swamp deer *Cervus duvauceli duvauceli* in the terai area of Utter Pradesh (U.P) over recent years is a case in point. Descriptions on Barasingha *Cervus duvauceli* have appeared sporadically in hunting literature of the last century. Blanford (1888-91) was however, the first to give an account of the distribution of the species. Brander (1923) presented more information on the Barasingha and made a distinction between the Barasingha in northern India and those in central India. Ellerman & Morrison-Scott (1951) subsequently distinguished two subspecies: *Cervus duvauceli duvauceli* Cuvier 1823 and *Cervus duvauceli branderi* Pocock 1943. Later, Groves (1982) distinguished the northeast race as new sub-species and named as *C. d. ranjithsinghai.* Now three subspecies of swamp deer are known to occur in the Indian subcontinent namely *Cervus. d. duvauceli* distributed in northern India, *Cervus. d. brandreri* distributed in Kanha National Park in central India and *Cervus. d. rangitsinghai* distributed in Assam. Preferred habitats of the swamp deer are marshes and grassland (Sankaran 1990). The ruthless destruction of terai ecosystem for agriculture and human settlements has led to large-scale

fragmentation, shrinkage and degradation of these unique vegetation types. Simultaneously, the population of mammalian and avian species such as one horned rhino *Rhinoceros unicornis*, tiger *Panthera tigris*, swamp deer *Cervus duvauceli*, hispid hare *Caprolagus hispidus* and Bengal florican *Eupodotis bengalensis* witnessed serious decline in their abundance and distribution. Due to repatriation of settlers through out the terai of UP, most of the grasslands have been converted into agriculture in the past (Sankaran 1990). Forestry policies have often considered grasslands as "wasteland". The resulting plantation of exotics and indigenous tree species in grassland has converted several good grassland habitats into woodland (Rahmani *et al*. 1988). The swamp deer or Barasingha in the historic past ranged over a large tract along the foot hills of the Himalayas in the alluvial and flood plains between the Indus in the west to the Brahmputra in the east extending to the Sundarbans, and to the south as far as the Godavri. The distribution range of swamp deer was reduced considerably due to habitat destruction and over hunting and at the turn of the 20th century; the species survived in swampy areas from upper Assam extending to the Sundarbans in the east to the Indo-Gangetic plains in the west and south wards up to eastern Maharashtra (Jerdon 1874, Bhadian 1934, Prater 1980, Brander 1982). The trend in range reduction continued and Schaller (1967) reported swamp deer from 28 localities only, of which five were in southern Nepal and the rest were in the Indian states of Uttar Pradesh (U.P.), Assam, West Bengal and Madhya Pradesh.

The status of subspecies of Barasingha *Cervus. d. duvauceli* was first assessed by Schaller (1967), who reported the presence of this subspecies

from 11 localities in northern India. Holloway later reviewed the status in 1973 that found Barasingha surviving in four localities out of 11 localities surveyed by Schaller in 1967. The four localities were in Pilibhit, north Kheri, south Kheri, and Bahraich. Sankaran (1990) estimated the Barasingha population to be 765 in whole of the Dudwa Tiger Reserve.

The Barasingha resemble red deer in size and appearance. It is a large, graceful deer, standing 44 to 46 inches high at the shoulder (Blandford 1888-91). A full grown stag weighs about 370 pounds (Brander 1923). Barasingha shows marked seasonal change in its coat color, animals in their summer coat are a rich chestnut brown on the back and somewhat lighter brown on the sides and belly and creamy white on the inside of legs, rump and underside of tail. The winter coat, which is acquired by hinds in November is dull to grayish brown. Adult stags have a long, coarse, dark brown, almost black coat, considerably darker than that of hinds and young stags. The hair on the neck is up to five inches long, giving the animal a prominent ruff (Schaller 1967). The chin and throat are whitish and so are inside the ears. The fawns have brown coat without spots. The first indication of the antlers is small bumps on the frontal bones, which appear at about seven months of the age in the fawns. Yearling stags have simple spike antlers. The first set of adult antlers consists usually of brow tine and a main beam with one or two forks. Very old stag may carry antlers with sometimes as many as 7 tines on each beam (Schaller 1967, Martin 1977).

1.2 Status

The Barasingha is highly endangered species listed in schedule 1 of the Indian Wildlife Protection Act (1972) and Appendix-I of the CITES. The

establishment of Dudwa National Park in 1977, was therefore, hailed as great event, because it meant strict legal protection to the habitat of largest surviving herd of this species.

1.3 Objectives:

The study was initiated with the following objectives:

1. To estimate the population status, distribution, abundance and structure of Barasingha C*. d. duvauceli.*
2. To investigate the habitat utilization pattern of Barasingha *C. d. duvauceli*.
3. To study food habits of Barasingha *C. d. duvauceli*.
4. To study the basic diurnal activity pattern of Barasingha *C. d. duvauceli*.
5. To suggest mitigation measures for threats to its conservation

CHAPTER-2

STUDY AREA

2.1 Historical Background

The history of the forests, included in the Park, dates back to 1861 when this area was taken over from khairigarh pargana and preserved as forest land. These forests

have all along been managed for producing railway sleepers from the sal *(Shorea robusta)* trees. The wildlife conservation did not receive much attention in the working plan of the area. However, the most important wildlife of the area i.e., swamp deer, remained ignored for all these years. Shooting against rules, coupled with heavy grazing and frequent fires started telling on the status of the wildlife of the area (Singh 2002).

Alarmed by this the Wildlife Preservation Organization of the U.P. Forest Department (constituted in 1956) initiated steps for developing the area as a sanctuary for swamp deer. As a result, Sonaripur Sanctuary covering a total area of about 63 sq. km was constituted. In 1977 the area was declared as a national park with an area of 614.32 sq. km. In 1987 the park was brought under the umbrella of the Project Tiger with an addition of 214 sq. km of the Kishanpur Wildlife Sanctuary. The two areas are not contiguous and the river Sharda forms a natural barrier between the two areas (Javed 1996).

2.2 Location

Dudwa National Park (DNP) lies between 28 27’ and 28 42’ N and 80 31’ and 80 57’ E, situated in the Lekhimpur Kheri district of Utter Pradesh (Javed 1996) and Jadi Tal area which is part of the Kishanpur Wildlife Sanctuary (28

27’ N and 80 22’ E). The notified area of the Dudwa National Park is 490.29 sq km. However, the adjoining 124.02 sq. km of the buffer area of the Park, along the northern boundary, functions for all practical purposes as a part of the park, making the area a compact block of 614.32 sq km. The Sharda river, better-known landmark near the area, is about 20 km away from the southern boundary of the DNP. On the other side of the Sharda lies the Kishanpur Wildlife Sanctuary, which covers an area of 227 sq km. During floods, Sharda River gets linked through Channels like ‘Harinagar, Bhagahar’. This hydrological aspect of the area is significant from wildlife conservation perspective, because the wildlife of both Dudwa and Kishanpur Protected Areas get genetically linked (Singh 2002).

2.3 Topography

In its general aspect, the Park is a vast alluvial plain, the doab of Mohan and Suheli rivers, scoured with large number of seasonal water channels. The alluvial land falls into two categories- the high alluvium under Sal and low alluvium under grasses and miscellaneous species (Leete 1902). The general slope of the area is from northwest to southeast. The altitude above sea level ranges from 182 m in the extreme north to 150 m in the southeast, and falls nearly by 30 m in 40 km.

2.4 Geology and soil

The underlying soil of these forests consists of the alluvial formation of Gangetic plains, (Singh 2002) showing succession of beds of sand and loam, varying in depth according to the configuration of the ground. The surface soil is sandy in the more elevated portions, loamy in the level uplands and clayey in the depression.

2.5 Climate

The climate of area is tropical monsoon type. There are three distinct seasons.

Winter Season	15 October to 15 March
Summer season	15 March to 15 June
Rainy Season	15 June to 15 October

The nights during winter are very chilly and foggy and often fog remains till most part of the day. From April to June the days are very hot and humid.

2.6 Rainfall

Most of the rain falls between June and September and accounts for about 90% of the total precipitation. The average annual rainfall is about 150 cm.

2.6 Temperature

The maximum and minimum temperature in January ranges between 19-23 ^{0}C from year to year where as minimum varies from monthly average of 8 ^{0}C to 9.1 ^{0}C respectively and during this period frost occurs in grassland. May to June are the hottest months and temperature fluctuates between 38 to 45 ^{0}C. The weather remains pleasant between February to April.

2.7 Winds

The prevailing winds are westerly and they increase in force in March and usually blow strongly in April and May, becoming very hot till the approach of monsoon.

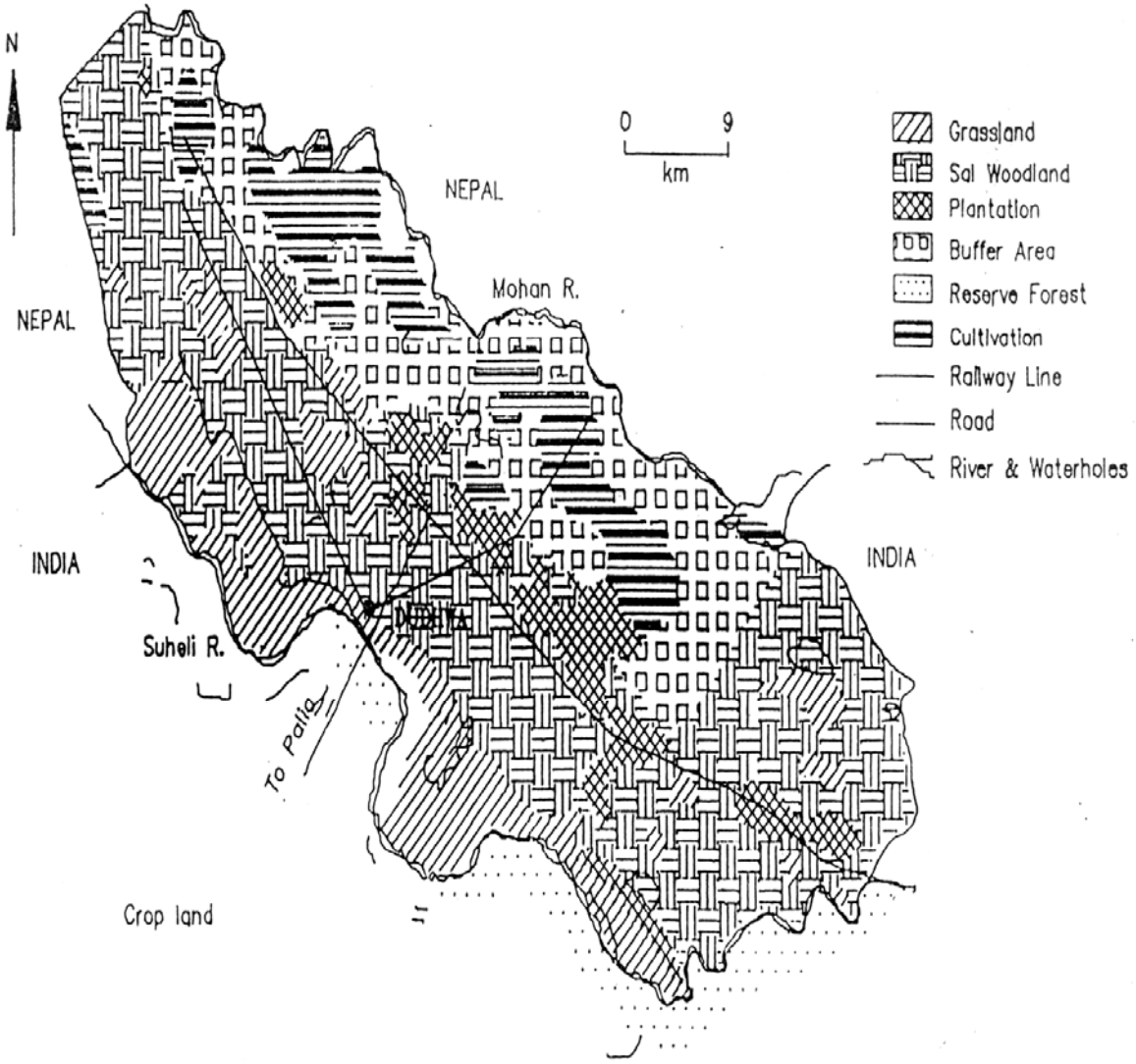
2.8 Frost

Frost frequently occurs in the open grasslands (locally called phantas) and is often severe. There is no frost within the forests.

2.9 Drainage

The two rivers, flowing through the area, along the boundary, are Suheli and Mohan. Both of them originate in Nepal and bring plenty of water during the rainy season. Suheli enters the area in the north- west and flows with a very irregular course, fed by several small tributaries \ streams, most of these flown down from

Figure 1. Map of Dudwa National Park under different vegetation types.



higher land on the north draining the central depression of the forest tracts. The Mohana river enters the area near Gauri Phanta and flows south-east to join Kauriala. At Chandan Chowki, the river is considerably deep, with steep and well-defined banks (Bhatia 1953). The Sharda river, a better known land mark near the area is about 20 km away from the southern boundary of the Dudwa National Park. On the other side of the Sharda lies the Kishanpur Wildlife Sanctuary (227 sq. km). During flood, Sharda river gets linked through channels like 'Harinagar Bhagahar'.

2.10 Flora

The composition of the flora of the area relates to Northern tropical semi-evergreen forests, North Indian Moist Deciduous Forests, Alluvium Sal Forests, Western Light Alluviual Sal Forests, Moist Sal savannah Woodland and Tropical Seasonal Swamp Forests (Champion and Seth 1968)

2.11 Fauna

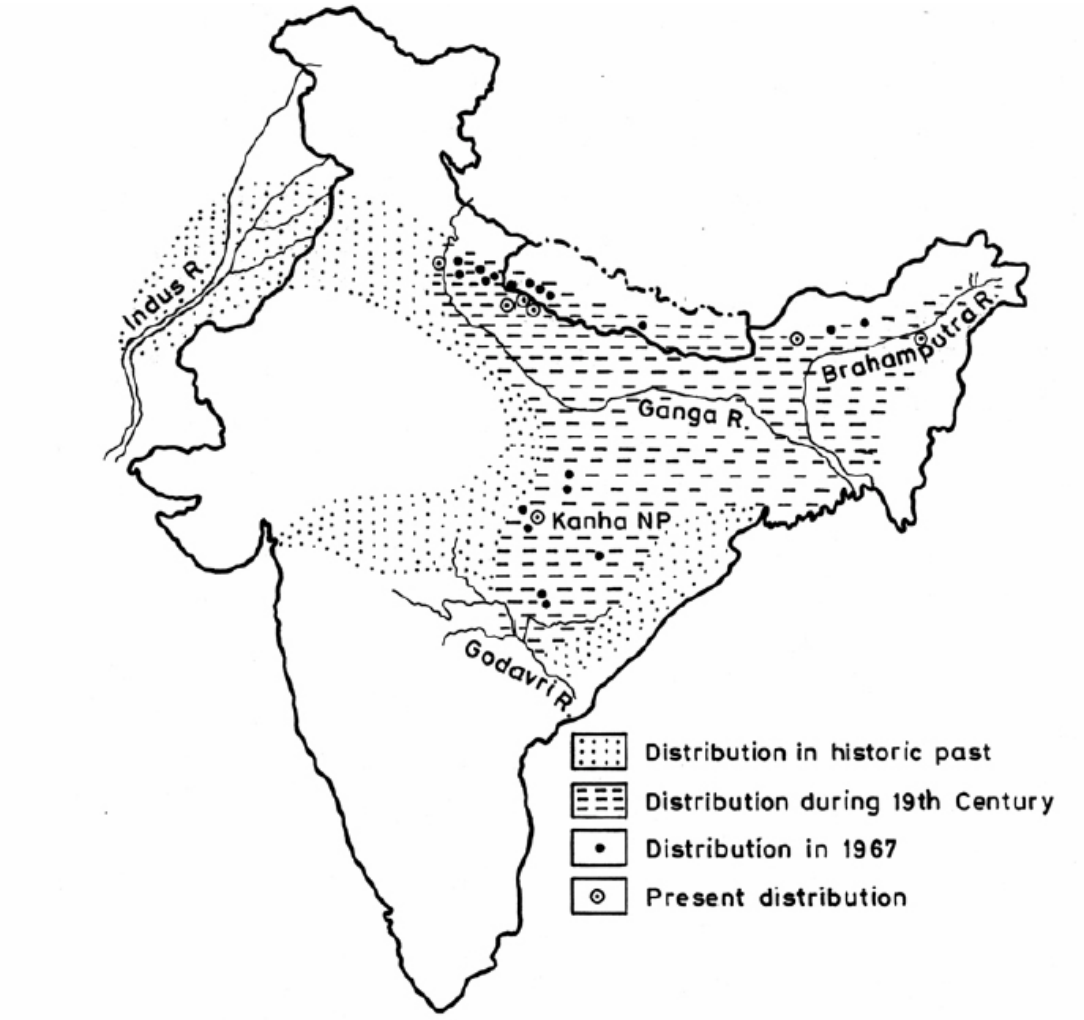
Forest in Dudwa lies well out side the hills in the northern part of the Gangetic Plain and is perhaps the last strong hold of the fauna of the Indo-Gangetic tract left so far. The innumerable nalas and various Phantas covered with tall grasses provide adequate cover, food, and water for wild animals. The area is very rich in bird life and 449 species have so far been identified including migratory birds (Singh 2002). There are 31 species of mammals, 8 species of turtles reported from the Park, of which the Indian Eyed Turtle *Morenia patersi* is the new species for Utter Pradesh. Fifty-seven species of insects, 8 species of fishes, and 22 species of reptiles have been reported from the Park (Javed 1996).

Table 1.1. Area of Dudwa National Park under different Vegetation types as computed from satellite data.

S. No.	Vegetation Type	Area in sq.km	% of park Area
1	Sal (*Shorea robusta*) dominated dense forest	332.35	54.09
2	Grassland	113.14	18.41
3	Shisham (*Dalbergia sissoo*) dominated forests with grasses	42.11	6.85
4	Teak (*Tectona grandis*) plantation	40.11	6.52
5	Jamun *(Syzygium cuminii*) dominated forest found along streams	31.97	5.19
6	Khair (*Acacia catechu*) dominated open forest with grasses	21.16	3.44
7	Water bodies and wetlands	18.33	2.98
8	Eucalyptus plantation	14.22	2.31
9	Forest rest Houses, staff Quarters, roads, railway line etc.	01.00	0.16
	Total Park Area (including buffer area)	614.32	100

Source (Singh 2002)

Figure 2. Past and present distribution of *Cervus duvauceli*



CHAPTER-3

METHODOLOGY

3.1 Population status, distribution and abundance

Direct observations were made to collect data on population status and distribution of the Barasingha. In order to collect data on the current status and distribution of Barasingha, field surveys were carried out in Dudwa-Kishanpur Protected Areas known to harbour Barasingha populations. In each protected area, Barasingha was counted by elephant back; machan and vehicles. Apart from this, random searches were also attempted in different grassland patches.

Swamp deer were counted mostly from vehicle, occasionally on foot from machans in the study area and less frequently from elephant back. All data pertaining to herd size composition were collected mainly in a fenced area of 27 sq. km, where 5 rhinos were reintroduced in 1984. Other areas occupied by swamp deer were also visited frequently to assess the population. The grassland area of Kakraha was surveyed regularly through fixed routes between dawn and dusk. The areas not accessible by road network were visited on foot. All encountered Barasingha, were aged and sexed whenever possible and location and activity of each group was also recorded during the time of observation. The term “group” applies to all units of animals seen in one sighting.

Five sex and age classes were distinguished. These are a) adult males, b) adult females, c) yearling males, d) yearling females and e) fawn (Schaller 1967, Martin 1977).

3.2 Forage preference

Forage preference was determined by a careful examination of feeding sites (Martin 1977). After a Barasingha or group of Barasingha left the feeding site and moved out, feeding site was inspected and grasses consumed by group were recorded.

3.3 Habitat utilization

Two approaches have so for been used for quantification of habitat utilization. The first approach was based on the direct sighting, while the second based on indirect evidences e.g. pellet groups. Data on habitat utilization of swamp deer were collected by both direct and indirect methods. Since the data based on direct sighting reflect the habitat use only at the time of observation and thus a possible source of error may occur due to chance events, past disturbance or immediate presence of the observer. Therefore, in order to minimize this bias, data on habitat utilization of the swamp deer was also collected by indirect method.

Whenever a group of Barasingha was encountered, I used to go to the exact location and four animal-centered circular plots were laid at the location of sighting. The location of circular plot was exactly where the animal was seen. To know the grass composition on each plot, all grasses or grass like plant species were counted in each plot to know the grass frequency, density, richness and diversity in each plot. Grass cover was estimated visually and ranked them in an ascending order.

Nil = 0

Low = 1

Medium = 2

High = 3

The pellet group method, reviewed by Neff (1968), Overton (1971), Putman (1984) has been used extensively for finding out habitat use, abundance and

population size estimation of a number of ungulates species. Pellet group count method was used as an indirect method for assessing habitat use of Barasingha. The pellet groups of Barasingha can be distinguished from that of other ungulate species such as hog deer (*Axis porcinus*) on the basis of size and shape. The pellet groups were counted on each plot to know whether the animals used the plot or not. Only fresh droppings were recorded. The pellets, which were either partially disintegrated or completely disintegrated, were not included in the sample to avoid error.

Mean grass height was also measured randomly in each plot. Data on various disturbance factors such as fire, cattle dung, grass cutting by local people were also collected at each plot. To determine habitat utilization pattern, direct animal sighting plots (1 m radius) were compared with random circular plots of same radius (1 m) laid in the study area.

3.4 Activity pattern

The activities of swamp deer were broadly classified in to four categories namely grazing, walking, standing/scanning and resting/lying (Jarman and Jarman 1973). The other activities like urination, defecation, fighting and courtship display etc. that are spaced with these major activities were not considered. Routine observations were made, whenever a Barasingha or group of Barasingha was encountered and information about activities was recorded on data sheet. After every ten days gap, continuous ten hour observations (07:00 to 17:00) were made on activity pattern of species.

3.5 Data Analysis

The sightings of swamp deer in six different sites of Dudwa-Kishanpur Protected Areas were summarized separately to know the status and distribution in each surveyed site. One-way ANOVA was performed to find out differences in mean group size values of swamp deer in six different sites as well as across different months.

The number of pellet groups of swamp deer in each sampled plot was used to calculate pellet group density (pellet group/m^2) in each plot. Data of 360 plots were used in analyses. These values were pooled together to calculate mean pellet group density for swamp deer.

To find out the correlation between pellet group density of swamp deer with the habitat parameters, Pearson's product movement correlation coefficient was performed. Density of grasses was calculated for each sampling plot, by using the formula Density (D) = number of individuals/area

Species diversity and richness of grasses for each plot were calculated by using Shannon Weiner index (H') for species diversity and Margelef's index (R1) for species richness by using the formula given below. The analysis was done in SPECDIVERS; a DOS-based modified module of STATISTICAL ECOLOGY (Ludwing and Reynolds 1983) was used to calculate these values.

(H') = $-\sum pi \times \log pi$ and (R1') = s-1/ ln N.

Where, pi = proportion of ith species in sample and S = number of species in sample and N = number of individuals.

To find out differences between habitat variables of Random and Animal plots, Paired t-test was performed. To understand habitat use of swamp deer, data were subjected to Principal Component Analyses (PCA). All the quantitative data in the data matrix were transformed using log and Arcsine transformation function to improve normalcy in the data. Factor analyses were used to reduce the dimensionality of habitat variables. The first two factors which explained maximum variation in the data set were used for interpretation. All the statistical tests were performed using statistical package SPSS (Norusis 1990).

CHAPTER-4

RESULTS

4.1 Status and distribution

A total of 125 groups of swamp deer were encountered during the study period across different sites. The maximum numbers of groups were observed in the Kakraha area, while the minimum number of groups in Nagra Tal.

Across different sites in both Dudwa-Kishanpur Protected Areas, the largest herd of Barasingha observed in one day, during the period of study, was in Kishanpur Wildlife Sanctuary (Jadi Tal), which comprised of 293 individuals and the lowest herd was observed in Nagra Tal, comprising 3 individuals. It is clear that Kishanpur Wildlife Sanctuary (Jadi Tal) harbour the highest population of Barasingha and Nagra tal in Dudwa National Park, the lowest population of the species. The population status and distribution in other areas of Dudwha National Park is given in the Table 4.1.

4.2 Group Size

The overall mean group size of swamp deer was found to be 35.33 $\pm$ 5.25 S.E. across the five different sites. Largest group size was reported from Kishanpur Wildlife Sanctuary (Jadi Tal) 114 $\pm$ 32.88 S.E and lowest in Dudwa National Park (Badi Tal) 11 $\pm$ 9 S.E (Table 4.2). The group size of swamp deer varied significantly across different sites ($F = 6.1$, d.f. = 5, $P < 0.05$).

The overall mean group size of swamp deer in all the three month (March, April and May) was 36.42 $\pm$ 5.42 S.E. Where as, the mean group size was observed highest in the month of March 54.81 $\pm$ 11S.E. and lowest in the month of May 16.44 $\pm$ 4.24 S.E. (Table 4.3). The mean group size of swamp

deer varied significantly across different months (F = 4.4, d.f. = 2, P<0.05, One way ANOVA).

4.3 Age and Sex ratio

Out of a total number of 4385 individuals observed in both Dudwa-Kishanpur Protected Areas, 1719 (37.0%) were adult and yearling females, 867 (23.0%) were males including yearlings and 745 (17.0%) were fawns. The male to female ratio based on above data in both Dudwa-Kishanpur Protected Areas was 1 male:1.6 females. The population composition of both Dudwa National Park and Kishanpur Wildlife Sanctuary is provided in Figure 4.1and Figure 4.2 respectively.

The proportion of various age-sex categories in different sites of Dudwa-Kishanpur Protected Areas is given in Table 4.4. In all the five sites Barasingha population showed biased sex ratio in favour of females while male to female and fawn to females ratios were relatively the same in Dudwa National Park, but relatively higher in Kishanpur Wildlife Sanctuary (Jadi Tal) (Table 4.5).

4.4 Hard and soft antlers

Out of 119 observations, the overall average group of males seen in hard antlers was 6.2± 0.95 S.E. Month-wise it was highest in March 10.6± 1.9 S.E. when swamp deer start shedding their antlers and lowest in May 1.7 ± 0.71 S.E. (Table 4.6). The results of ANOVA revealed that males seen in hard antlers in all the three months varied significantly (F =8.644, d.f. = 2, P<0.05, One way ANOVA)

Table 4.1. Population status and distribution of swamp deer in Dudwa-Kishanpur Protected Areas.

Sites	N	NV	Minimum	Maximum
Jadi Tal*	11	9	14	293
Kakraha	79	87	1	246
Satiana	17	30	1	93
Bankey Tal	15	18	8	19
Badi Tal	2	3	2	20
Nagra Tal	1	3	3	3

N = Number of observation, NV =Number of visits,

***= Kishanpur Wildlife Sanctuary**.

Table 4.2. Mean group size of swamp deer in different sites of Dudwa-Kishanpur Protected Areas.

Sites	N	Mean	± S.E.	Minimum	Maximum
Jadi Tal*	11	114.00	32.88	14	293
Kakraha	79	33.92	5.74	1	246
Satiana	17	12.52	5.82	1	93
Bankey Tal	15	14.20	0.82	8	19
Badi Tal	2	11.00	9.00	2	20
Total	124	35.33	5.25	1	293

N = number of observations, S.E. = Standard error

Table 4.3. Mean group size of swamp deer across different months in Dudwa-Kishanpur Protected Areas.

Month	N	Mean	± S.E.
March	49	54.81	11.04
April	52	26.01	5.91
May	18	16.44	4.24
Total	119	36.42	5.42

N = Number of groups, S.E.= Standard error

The overall average group of males seen in soft antlers in these three months was 0.82 ± 0.24 S.E while it was highest in May 2.7 ± 1.04 S.E. When almost all-adult males shed their antlers and lowest in March 0.18 ± 0.16 S.E, when swamp deer start shedding their antlers. (Table 4.7). The number of males observed in soft antlers varied significantly across different months ($F = 4.4$, d.f. =2, $P<0.05$ One way ANOVA). Percentage of males seen in hard and soft antlers is shown in Figure 4.

4.5 Food preference of Barasingha

Many types of habitat may occur within a home range of an animal but it may utilize only a few of these available patches. Preference for certain habitat types can be due to food preference, cover or other factor. However the dominance of a species and its distribution pattern has a great deal to do with its preference rating.

In a heterogeneous grassland habitat standardized observations are almost impossible. Smith (1952) has reported on this central problem of food habit studies. Table (4.8) shows the main grasses or grass like plant species that Barasingha consumed in the month of summer. Indications of food preference are based on a large number of unsystematic observations. Identification of grazed plants was made on the spot, immediately after the grazing animal had been watched through binoculars. Swamp deer in Dudwa National Park feed largely on aquatic vegetation growing in shallow swamps and new shoots of grasses that grow after control burning of grassland. The Barasingha do not feed upon bushes and leaves of young trees and hence never enter into the forest area for feeding. During the study period, swamp deer was never seen feeding on bushes and leaves

Table 4.4. Proportions of different age-sex categories in five different sites of Dudwa-Kishanpur Protected Areas.

Sites	AM	AF	YM	YF	FN	Unidentified
Jadi Tal*	18	27	6	10	17	19
Kakraha	13	30	5	8	16	20
Satiana	16	35	5	10	19	14
Bankey Tal	12	43	6	18	21	0
Badi Tal	1	36	50	0	9	0

AM = Adult male, AF = Adult female, YM = Yearling male, YF = Yearling female

FN = Fawn, *Kishanpur Wildlife Sanctuary

Table 4.5. Number of males (AM) and Fawns (FN) per 100 females in five different sites of Dudwa-Kishanpur Protected Areas.

Sites	N	AM	FN
Jadi Tal *	1015	62	62
Kakraha	2128	43	54
Satiana	182	47	55
Bankey Tal	213	27	47
Badi Tal	22	72	18

N= Number of animal classified, * Kishanpur Wildlife Sanctuary

Figure 3. Percent distribution of groups of Swamp deer in different group size categary

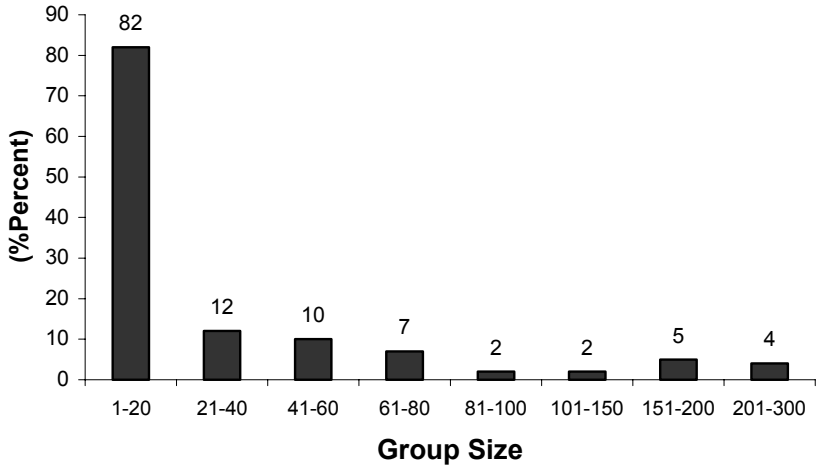


Table 4.6. Average number of males seen in hard antlers across different months in Dudwa-Kishanpur Protected Areas.

Month	N	Mean	± S.E	Minimum	Maximum
March	49	10.61	1.97	0.00	53
April	52	3.61	0.82	0.00	28
May	18	1.72	0.71	0.00	11
Total	119	6.21	0.95	0.00	53

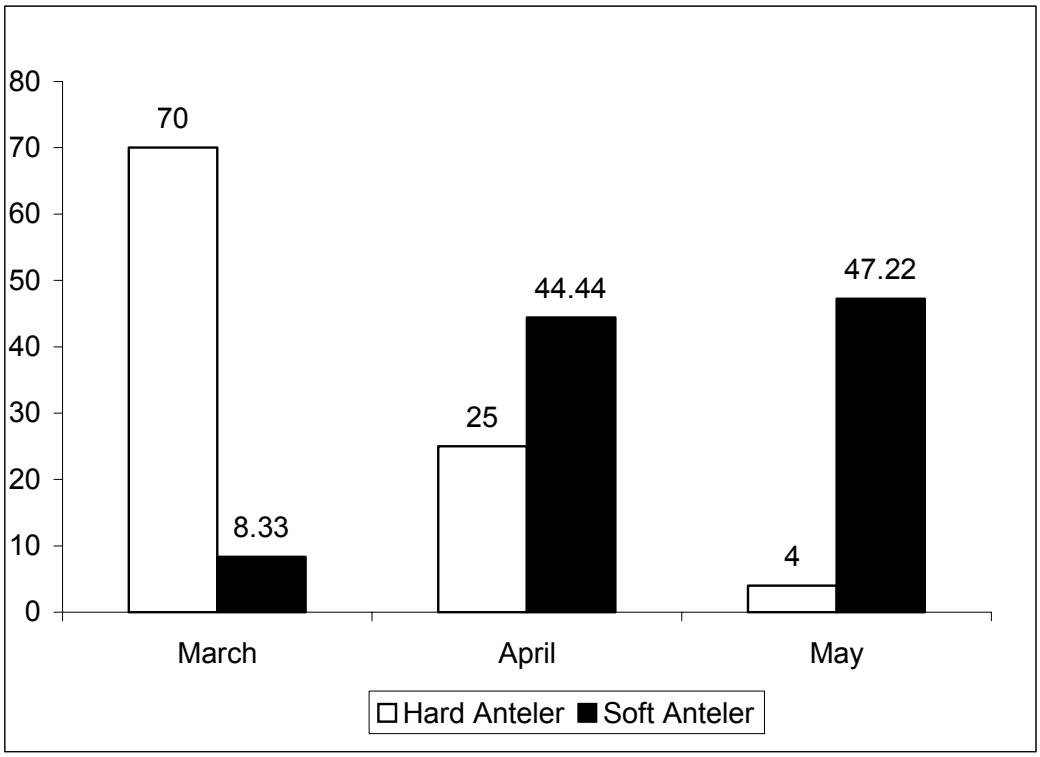
N = Number of groups, S.E. = Standard error

Table 4.7. Average numbers of males seen in soft antlers across different months in Dudwa- Kishanpur Protected Areas.

Month	N	Mean	± S.E	Minimum	Maximum
March	49	0.18	0.16	0.00	8
April	52	0.92	0.37	0.00	16
May	18	2.27	1.04	0.00	18
Total	119	0.82	0.24	0.00	18

N = Number of groups, S.E. = Standard error

Figure 4. Percentage of males seen in hard and soft antlers during the month summer.



of young trees and no swamp deer were seen in the forest area.

4.6 Leadership in Swamp Deer

Adult female usually leads mixed herds, 30 movements of large herds recorded during three months i.e., March- May 2005, female led 28 times and stag only twice. It was found that any female in the herd may lead the group but her position depends on the number of followers, if no members of herd follow her, she either joined the herd again or moved solitary.

4.7 Habitat utilization

The result of correlation analysis using Karl Pearson Correlation Coefficient showed statistically significant positive correlation between mean pellet group density of Barasingha and that of grass diversity ($r = 0.11$, $P<0.05$). However, the pellet group density showed statistically significant negative correlation with grass height ($r = -0.113$, $P<0.05$). The pellet group density also showed negative correlation with grass density, grass richness and grass cover but these were not statistically significant. (Table 4. 9).

Paired t test was performed to find out difference between mean pellet group density, grass density; grass richness, grass diversity, grass height and grass cover between random and animal plots. The results showed that mean pellet group density ($t = 4.0$, d.f. = 1, $P<0.001$) grass density ($t = 4.227$, $P < 0.001$) and grass height ($t = 16.92$, d.f. = 1, $P<0.001$) and grass richness ($t = 2.4$, d.f.=1, $P<0.001$) differed significantly across random and animal plots. However the grass diversity and grass cover did not differ significantly between random and animal plots (Table 4.10).

4.8 Factor governing habitat use

The PCA performed on the habitat parameters between random and animal plots extracted three components accounting a total cumulative variance of 61%. Out of three extracted principal component system, PCI accounted for 31% of variance and PCII accounted for about 17% f variance. The two components together explained 49% of total variance. Table (4. 11)

The PC I was positively correlated with grass diversity, density of *Vitiveria zizanioides* and density of *Cynodon dactylon* whereas density of *Imperata cylindrica* showed negative correlation. The density of *Desmostachya bipinnata*, density of *Saccharum spontaneum* and grass height showed positive correlation with PC II.

The distribution of random and animal plots in relation to first and second components is shown in Figure 5. It indicates that Swamp Deer prefer habitat with high grass diversity with high density of *Vitiveria zizanioides* and *Cynodon dactylon* and moderate grass height and density of *Desmostachya bipinnata* and *Saccharum spontaneum.*

4.9 Activity pattern

The morning activity of Barasingha during summer ceased by 0700 or 0800 hours, when they either moved into the shade or rested in the open. Nonetheless, a herd sometimes grazed intermittently throughout the day. A resting herd was often loose and scattered. The activities reached their peaks during afternoon (1200 to 1300 hours) when about 90% of animals were active.

An analysis of various major activities revealed that animals mostly rested during the daytime in summer. The peak period of grazing corresponded with

a steep fall in resting, walking and standing. During the peak period of grazing, no animals were seen resting and during peak period of resting, no animals were seen active (Figure 9). A prominent behavioral pattern of the Barasingha, which was observed during the study period, was ear weaving when walking or standing but particularly when resting in a compact herd, the animals waved their large ears back and forth steadily

Table 4.8. Grasses or grass like plant species consumed by swamp deer during the month of summer.

Scientific name	Local name	In take
Cynodon dactylon	Doob	++
Carex spp.	Badai	++
Desmostachya bipinnata	Kus	+
Dicanthium arrulatum	Basi	+
Dendrocalamus strictus	Bans	+
Imperata cylindrica	Mayari	+++
Phragmites karka	Narkul or nar	+
Saccharum munja	Munj	+
Saccharum spontaneum	Kans	++
Selerostachya fusca	Retwa	-
Saccharum narenga	Tawar	++
Vitiveria zizanioides	Khas	++

high preference= +++, medium preference= ++, low preference= + very low or none =-.

Table 4.9. Correlation between mean pellet group density of barasingha with different habitat parameters.

Habitat parameters	Correlation value
Grass density	- 0.005
Grass richness	-0.034
Grass diversity	0.119*
Grass height	-0.113
Grass cover	-0.011

Table 4.10. Paired t test between habitat variables of random and animal plots in the study area in summer season.

Variable	Animal Plot(Mean)	Random plot (Mean)	Mean difference	T value	Significance
Pellet group density	0.068	0.037	0.03(±0.007)	4.02	0.001
Grass cover	1.48	1.43	0.05(±0.02)	1.69	0.092
Grass density	2.13	2.02	0.10(±0.02)	4.22	0.001
Grass diversity	0.0835	0.0831	0.0004(±0.004)	0.10	0.921
Grass height	1.48	1.77	-0.28(±0.01)	-16.92	0.001
Grass richness	0.17	0.14	0.03(±0.17)	2.42	0.01

Table 4.11. Principal component Analyses of Habitat variables of Animal and Random plots showing component loadings in Dudwa National Park.

Variables	PCI	PCII	PCIII
Grass density	-.807	-.100	0.263
Grass diversity	0.739	0.227	0.271
Grass height	0.227	0.524	0.160
Density of *Imperata cylindrical*	-.894	-0.05	0.05
Density of *Saccharum spontaneum*	-.444	0.567	0.264
Density of *Desmostachya*	-.463	0.609	0.03
Density of *Vitiveria zizanioides*	0.594	0.312	-.265
Density of *Carex spp.*	0.512	-0.09	0.651
Density of *Saccharum narenga*	0.246	-.834	0.179
Density of *Selerostachya fusca*	0.237	0.06	-.716
Density of *Cynodon dactylon*	0.563	0.301	0.187
% of variance	31.89	17.53	11.95
Cumulative %	31.89	49.42	61.37

Figure 5. Ordination of Random and Animal Plots of Swamp deer during summer season in Dudwa National Park.

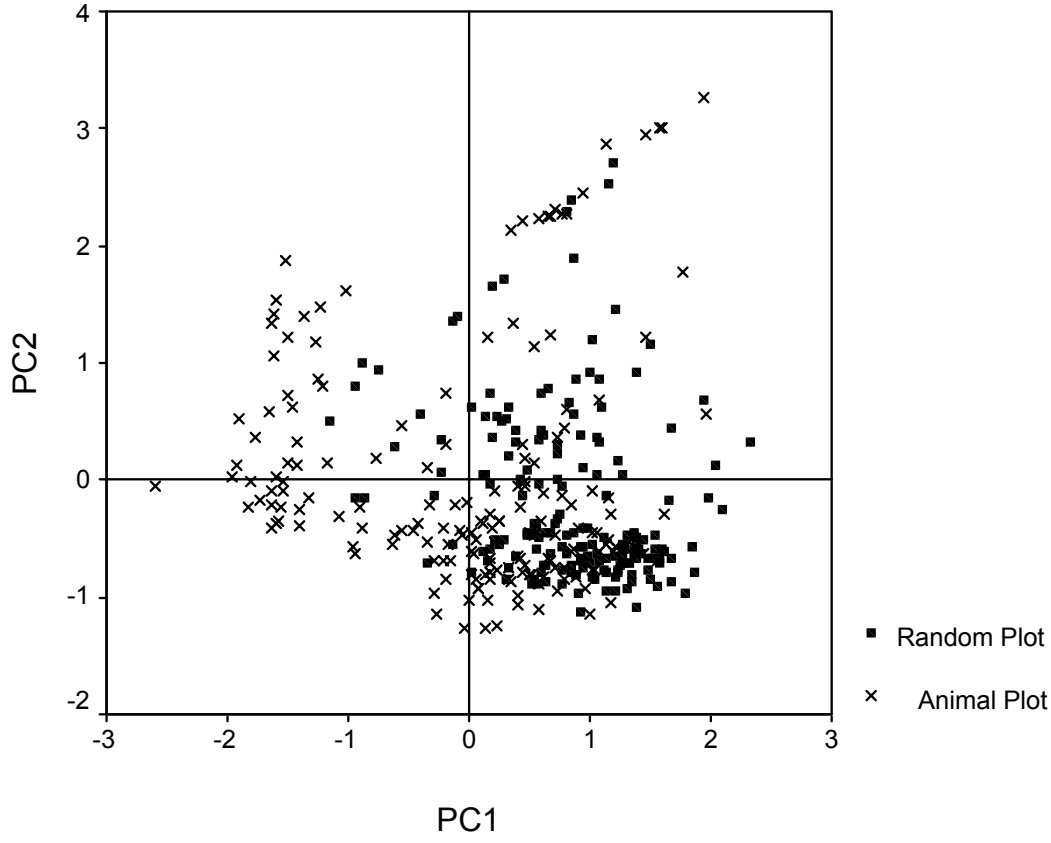


Figure 6. Component plots showing gradients for first and second components during summer season in Dudwa National park.

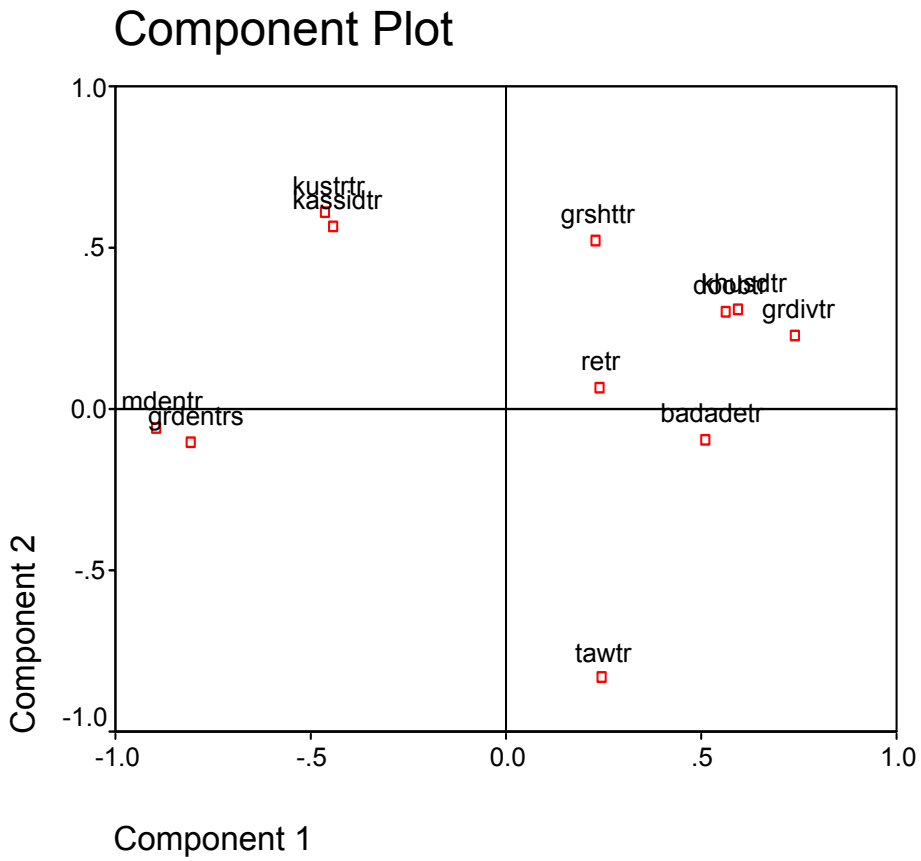


Figure 7. Activity budget of Swamp deer in Dudwa National Park.

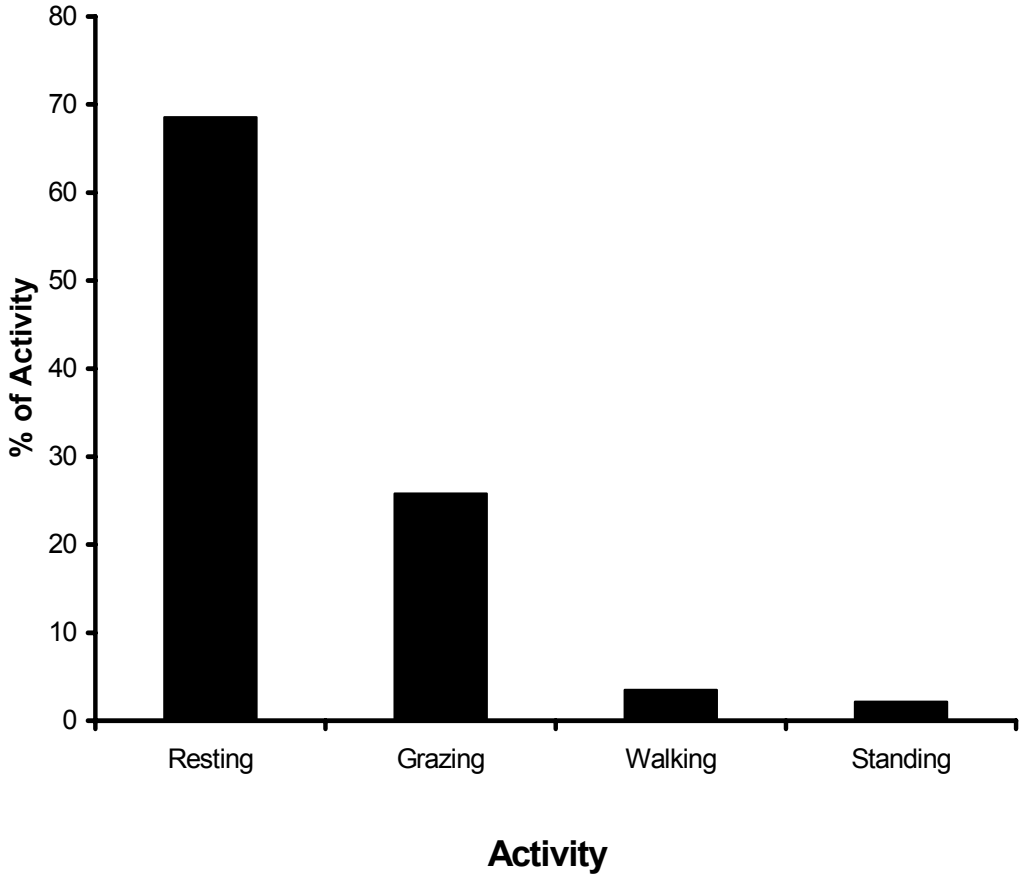


Figure 8. Activity budget of an adult stag barasingha in Dudwa National Park.

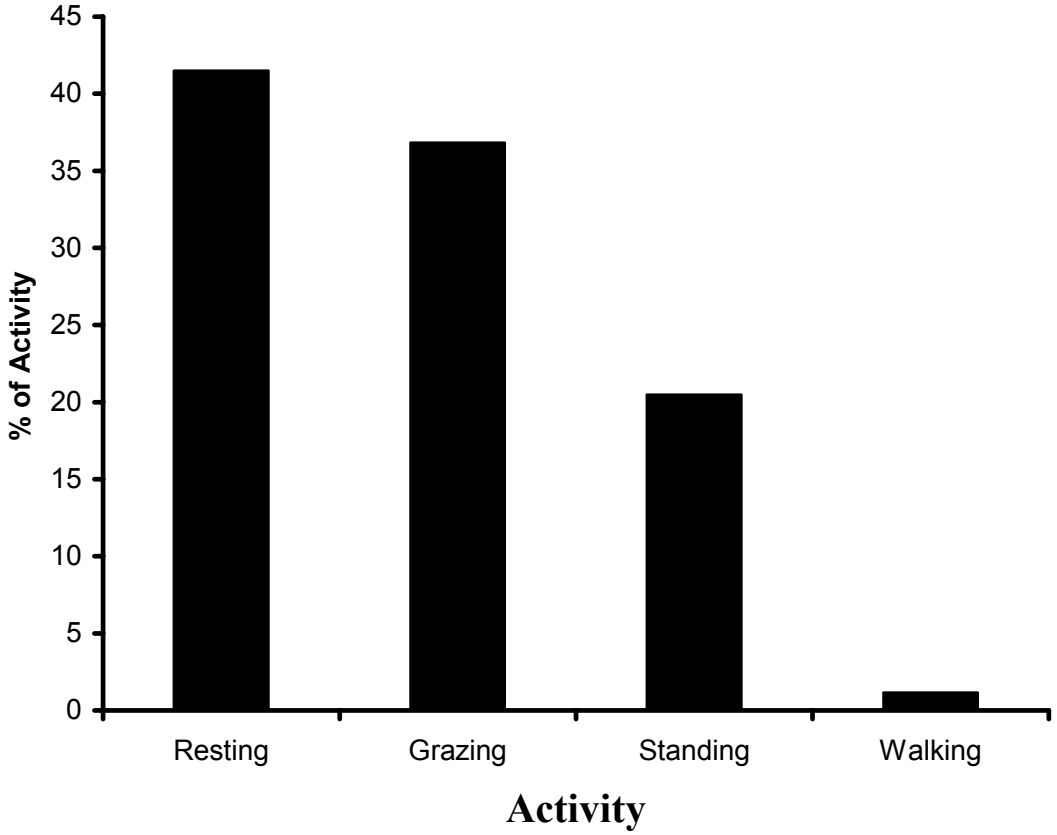
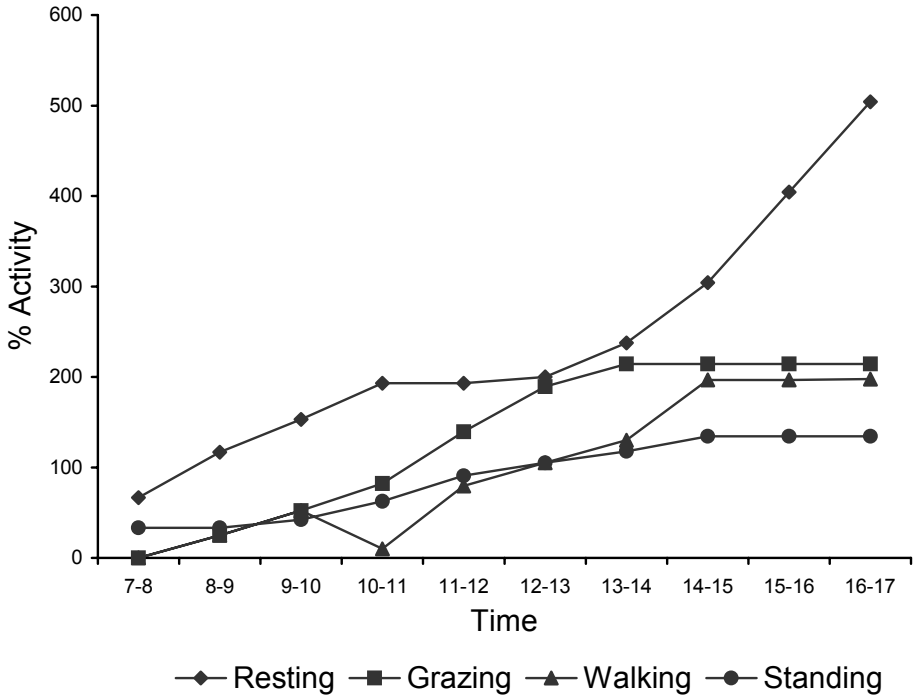


Figure 9. Diurnal activity of Swamp Deer in Dudhwa National Park.



CHAPTER-5

DISCUSSION

5.1 Status and Distribution

The methods of estimating size of ungulate population fall into two categories: direct and indirect method. The choice of method depends on a variety of factors such as behaviour of species, terrain, manpower available and the accuracy required in results. There has been rapid advancements in the field of population estimation using direct method such as line transect or more appropriately distance sampling (Burnham *et al*. 1980, Maleland *et al.* 1993). Many studies have utilized distance sampling to produce estimation of population densities for different taxa in a variety of habitats. Under the present study which was carried out in Dudwa-Kishanpur Protected Areas, it was not possible to use the distance sampling for population estimation, because of the behaviour of the species which remain around the ponds (locally called tals) and also the high abundance of target species completely ruled out the possibility of use of direct method for population estimation. In all six surveyed sites of Dudwa-Kishanpur Protected Areas, the highest population of swamp deer was found in Kishanpur Wildlife Sanctuary (Jadi Tal). In Kakraha block of Dudwa National Park, which is now part of rhino enclosure where seven rhinos *Rhinoceros unicornis* have been re-introduced, the second largest congregation of swamp deer was seen. There has been undoubtedly been an increase in the swamp deer population in this area, probably as a result of the deer being localized within the rhino-reintroduced area. Till 1988 Satiana region had the maximum numbers of swamp deer

found in the Park, but now the population is slightly less than that of Kakraha. The decline in numbers in Satiana is reflected as a general reduction in the total population. It is assumed that loss of habitat is one of the major causes for decline of many species of animals (Sankaran 1990). The major cause for decline in deer populations all over the world has been over exploitation by hunting (Holloway 1973). In India two other cervids, the Hangul *Cervus elaphus and the* Manipur brow antlered deer *Cervus eldi* have also been seriously affected by hunting (Kurt 1978, Ranjithsinh 1978). Singh (1984) postulated that one reason for decline of swamp deer population was a high fawn mortality. Holloway (1973) and Singh (1984) recognized that poaching was the main cause for decline of swamp deer population at Satiana. The decline of the Satiana population is due to the traditional movements into preferred habitats that lie in areas, which are not protected from poaching (Sankaran 1990, Pers. obser). Swamp deer are known to be traditional and have a strong tendency to return to their seasonal ranges over the year (Martin 1977, Schaaf 1978). In fact the tendency of returning to the rutting grounds appear to be so strong that in old fallow deer areas the rutting grounds were used for 50 years (Ueckermann 1968). In case of Dudwa National Park where such movements into agriculture areas was not found, the swamp deer population remained stable or increased over the year (Sankaran 1990, Pers. obser). One reason for decline of swamp deer population in Satiana is the hydrological impact of the siltation from Nepal hills, obstructed by the Soheli barrage has degraded the grassland of Satiana. The proliferation of unpalatable grasses have coarsened the habitat of swamp deer (A. Singh, Pers. Comm). According to Sankaran and Rahmani (1988),

out side migration of swamp deer in cultivated areas is the single greatest threat and has resulted in decline of swamp deer population in Satiana.

The BNHS study report (Sankaran and Rahmani 1988) and INTACH sponsored seminar on conservation of swamp deer held in Dudwa National Park on 1990 recommended the fencing of the park boundary in Satiana area as a solution to control dwindling swamp deer population. But according to Singh (2002) fencing of the Park boundary to restrict the swamp deer from moving outside the Park is not a desireable solution. According to him swamp deer is not an adaptable species like tiger. It is in fact an 'Exacting' species and needs its traditional and wintering feeding grounds to be restored to it. So, we should do everything possible to acquire Ghola and Gajraula tal areas and add these areas in to the Park to make Satiana area a complete ecosystem.

5.2 Group size and sex ratio

There are two main hypotheses regarding the herding behaviour of the ungulates. The first suggests that when in herds the animals can prevent or avoid the predation better than when alone (Hamilton 1971, Giest 1974, Eisenburg 1981). This could be done by a variety of methods including improved predator detection, active group defense and predator confusion. The other hypothesis links the animal social organization with the distribution and availability of its food supply (Altman 1952, Jarman 1974, Lowe 1966). The small species, it is suggested, have high nutritional requirements and has to feed in a highly selective way, they therefore cannot live in large groups. Larger species can afford to be less selective and can therefore live in larger groups (Mishra 1982). In species, which exhibit flexible social system, it is

suggested that they will form large groups when there is abundance of high quality forage but will be forced into smaller groups when food supply is less abundant and dispersed in distribution. In the study area the mean group size was found to be 35.33. Group size showed decline with advancement of summer season. It was highest in the month of March when there was enough palatable grasses due to control burning of grassland and lowest in the May, when grasses became tall and become unpalatable. Singh (1984) and Sankaran (1990) recorded almost similar herd size in these three-month. They found that group size of swamp deer in March was highest (32.6 and 28.52) and lowest in May (19.3 and 17.48) respectively. This study showed similar trend. Monthly variation in mean group size was also reported by Schaller (1967) in Kanha and Khan and Khan (1999) in Hastinapur Wildlife Sanctuary. Group size is an optimal response to the environment. Ecological factors appear to influence mean group size of Primates (Denham 1971, Crook 1972) and in African antelopes (Jarman 1974). Mean group size of swamp deer in Dudwa Tiger Reserve was found to be influenced by seasons indicating the direct relation with food availability. Martin (1977) found in Kanha that change in group size and composition coincides with change in vegetation type. In Dudwa National Park, it was observed that swamp deer form largest herd in open areas. The reason may be that the formation of largest herd could have been a response to feeding in open areas. A predator such as tiger would find it difficult to approach and make a kill in these large herds. The formation of large herds in open habitat has been observed in other species of deer also (Mitchall *et al*. 1977, Hirth 1977).

Age composition although often difficult to determine accurately in field is generally a reflection of the status of species in terms of its reproductive potential. A high percentage of young as compared to adults generally indicate a growing and thriving population. In contrast a small population of young usually indicates a low reproductive or senile group (Spillett 1966).

The overall sex ratio for swamp deer in Dudwa Tiger Reserve was 62 males:100 females. It was 50 males: 100 females in 1979-80 (Singh 1984) and 45 males:100 females in 1988-89 (Sankaran 1990). In hard ground Barasingha in Kanha, the sex ratio was 75 males: 100 females (Martin 1977). All these studies showed biased sex ratio in favour of females. Khan and Khan (1999) also observed biased sex ratio of swamp deer in favour of females in Hastinapur Wildlife Sanctuary. Martin (1977) found in Kanha that sex ratio between yearling male and yearling female was 1:1, but in this study yearling sex ratio was also biased in favour of females.

Variation in the sex ratio among yearlings may be due to uneven sampling. Long-term studies are required to ascertain the factor(s) responsible for uneven sex ratio and seasonal variation in it, as well as in group composition in swamp deer.

5.3 Food preference

The herbivore diet is influenced by several factors including anatomical and physiological characteristic of animals, community structure of plants, and its structure and chemical constituents (Owen-smith 1982). Although every grass species would be eaten by Barasingha on certain occasions. However the dominance of species and its distribution pattern in a certain locality has a

great deal to do its preference rating (Martin 1977). The most dominant species in Kakraha area of Dudwa National Park was *Impereta cylindrica.* So, the most conspicuous forage during the month of summer was *Impereata cylindrica,* a dense stand along water courses were regularly and extensively grazed upon throughout this season. Preference for a given habitat type is largely determined by the available vegetation within the area, providing food, water, minerals, shelter from climatic extremes and cover from predators (Jarman and Sinclair 1979). Food resources however not only vary between different habitat types, but also show marked seasonal variation within a given habitat, in response to change in rainfall patterns (Sinclair 1975).

5.4 Habitat utilization

The study on habitat use of swamp deer in Dudwa National Park was carried by direct and indirect methods. Both technique have been used extensively by various workers (e.g. Eberhardt and Van Etten 1956, Rogers *et. al*. 1958, Martinka 1968, Short *et al.* 1977, Green 1985, Khan 1993) to investigate the habitat use of different ungulate species in India and outside. The studies carried out so far provide substantial evidence that both approaches are equally useful in exploring ungulate -habitat relationship provided a good sampling design is used and observer's errors are reduced.

A pellet group is an indicator of presence of animal in any given vegetation type and has been used as standard method to study the habitat preference of ungulates by different workers (Khan 1989, Khan 1993, Orus Ilyas 2001). The data based on indirect evidences i.e. pellet groups has been analyzed in a variety of ways. The pellet group density of swamp deer show negative correlation with grass height, the reason may be that grass land cutting and

burning produced large rather than uniform areas of fresh new growth. Another reason may that predator such as tiger would find it difficult to kill the swamp deer in low grass height. While the pellet group density showed positive correlation with grass diversity. Laurie (1978) found similar phenomenon in *Rhinoceros unicornis.* He found that *Rhinoceros unicornis* reached highest densities in areas supporting the greatest habitat diversity.

Selection and use of a particular area by an animal are the result of proximate and ultimate factors (Hilden 1965). Proximate factors are those factors and cues on the basis of which animal evaluates a site. These may include structural features such as tree cover, under story, cover or slope. The presence or absence of other animal that may act as competitor or predator may also influence the habitat use. Animals may use such features as cues that they may not be the same as the factors that have resulted in evolutionary association between animal and habitat. Ultimate factors are those parameters that determine how successful, an animal is within a particular habitat (Litvetis 1991). An individual's ability to reproduce, obtain food and avoid predators are example of ultimate factors whereas studies of habitat use involves more measures of the proximate factors (Bookhout 1994). The data collected on various habitat parameters showed that swamp deer in Dudwa Tiger Reserve prefer low grass height and high grass diversity.

5.5 Activity pattern

Survivorship of animals depends on the time allocation to behaviors governing either the animal's probability of avoiding predators or its energy acquisition rate (Caraco 1979a). Feeding constitutes the major component of all activities in natural population (Rozin 1976). Bray (1974) and Panksapapp (1974) have

described both physical and physiological control of daily and seasonal feeding.

Activity profiles indicate the time budgeting of animals and suggest species utilise resources in relation to its environment. Majority of wild ungulates are with many phases of daily activity rhythm in which feeding bouts are interspersed with other activities. The present study in Dudwa National Park indicates that the daily activity pattern of swamp deer is of polyphase where feeding is interspersed with resting and walking. Resting and walking occurred almost throughout in between the feeding bouts. The animal spent most of its time for resting as evident from the activity time budget and grazing and walking was other major components. During the mid-day grazing was in peak, when about 90% of the animals were active. The morning activity of Barasingha ceased by 0700 to 0900 hours. Schaller (1967) found similar phenomenon in hard ground Barasingha during hot season. Cabon-Raezynska *et al.* (1983) reported many phases of daily activity of rhythm in which feeding was interspersed with resting phase. Thus its seems that there is a definite pattern as far as the major activities are concerned in the fixed hours of the day which are subjected to the seasonal variation. Other activities i.e. urination, defecation, displaying etc are subjected to seasonal variation. The availability of pasture and atmosphere seem to be the most strong ecological determinants in the seasonal variation of the basic type. The activity patterns of ungulates may also be influenced by sex and age of the animals (Jarman and Jarman 1973, Leuthold 1977). Another prominent behaviour of Barasingha was ear weaving. Ear weaving is possibly a cooling mechanism, a fan, which circulates the air around the head of the animal.

Schaller (1967) also found this mechanism in hard ground Barasingha during the hot season and he gave the reason that air weaving was possibly a cooling mechanism.

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