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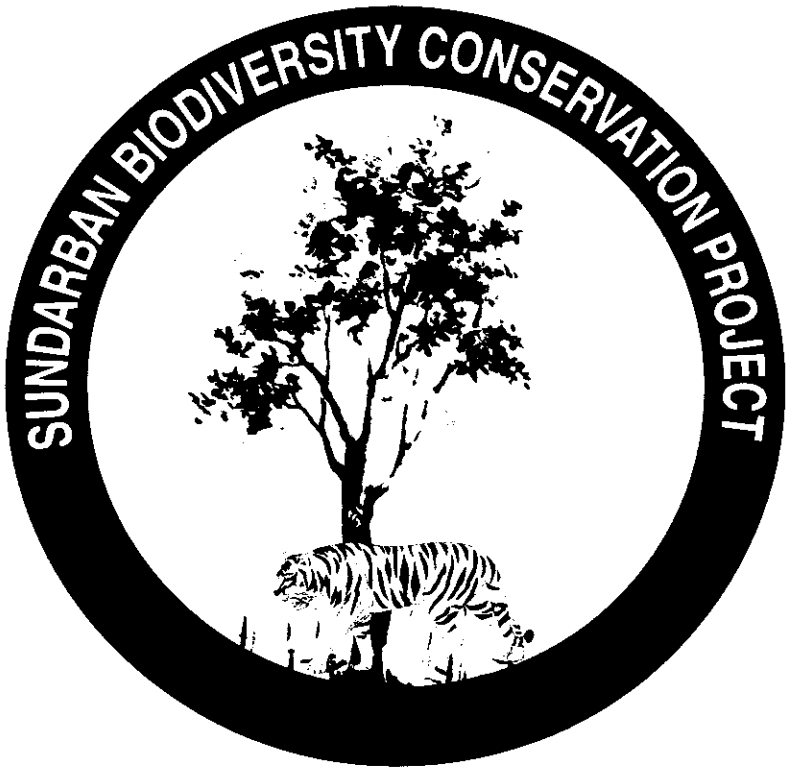

Internal Notes- In No. 79

Habitat utilization by spotted deer (*Axis axis*) in the Sundarbans

Dr. Md. Mostafa Feeroz, Associate Professor
Dept. of Zoology, Jahangirnatar University, Savar, Dhaka

September, 2003

ARCADIS Euroconsult, The Netherlands
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Sundarban Biodiversity Conservation Project

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Sundarbans Biodiversity Conservation Project (SBCP)

STUDY REPORT ON

Habitat utilization by the spotted deer (*Axis axis*) in the Sundarbans

by
Dr. Md. Mostafa Feeroz, Associate Professor,
Dept. of Zoology, Jahangirnagar University, Savar, Dhaka

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1. INTRODUCTION

1.1 General

The spotted deer is one of the most beautiful of all deer. The rufous brown coat with white spots persists throughout the life of the animal. The spotted deer is an animal of a pioneer ecotone species. Normally it dwells in open grassland in varying group sizes, comprising of all ages and sexes (Schaller 1967; Kurt 1978; Mayze and Moore 1990). The availability of drinking water, trees for shade, grass for forage, and an absence of high rugged terrain are the four factors that influence the spotted deer to concentrate in certain areas.

Spotted deer browse vegetation and feed on forbs, fruits and twigs of trees, including those thrown down by feeding monkeys (Kurt 1988c). They will keep feeding on vegetation as they move through different areas. The spotted deer is especially fond of grazing on short sprouting grasses. Stags tend to browse tree foliage by standing on their hind legs more often than females (Islam 2001).

The spotted deer is the principal prey species of the Bengal Tiger. The remains of spotted deer have accounted for as much as 70% of the content of the tiger scats (Reza *et.al.*, 2001). Spotted deer play an important role in the Sundarbans ecosystem as they form the main part of the diet of the tiger. In the Sundarbans, the spotted deer occurs throughout the forest although it is more abundant in the south in widespread meadows covered by grasses. The total population estimate of spotted deer ranges between 52,600 (Khan, 1986) and 80,000 individuals (Hendrichs, 1975).

1.2 Justification of the study

Apart from some surveys, very little information is available on the ecology of the spotted deer in the Sundarbans. Basic information on the ecology of this species in the Sundarbans came from the study conducted by Islam (2001). Information on population of this species in the Sundarban are available from some studies conducted by the Sundarban Biodiversity Conservation Project (IN no.27, 34). Systematic

studies have never been conducted on the habitat utilization and food preference of spotted deer in the Sundarbans. Seasonal changes bring either an abundance or scarcity of food in different habitats. It may influence the utilization of food and habitat selection of spotted deer.

Population densites as well as patterns of selection may vary in different sites according to the vegetation types present. Some studies suggested that the population of spotted deer may have increased beyond the carrying capacity of the area and the food supply for the animal may be insufficient due to over grazing (Hussain and Archarya, 1994). Sometimes it is suggested that control measures should be considered, but any decision should be taken carefully, as it is the principal prey species of the bengal tiger in the Sundarbans. Tiger densites are positively correlated with the biomass of prey species. To ensure the tiger's survival we must not only find out more effective ways to protect this cat and its habitat, but we should also explore all avenues to protect, maintain and increase cervid populations (Sunquist *et al.*, 1999). To develop an effective management plan for both the spotted deer and its predator, the bengal tiger, a systematic study is essential on habitat utilization and feeding ecology of the spotted deer.

1.3 Aims and objectives of the study

Conservation of nature and natural resources is now a global concern. Without proper scientific field knowledge, conservation and management of nature is impossible. At present, no quantitative field data are available on the habitat utilization by the spotted deer in the Sundarbans. The main aim of this research is to study the habitat utilization and food preference of spotted deer in the Sundarbans. Specific objectives are as follows:

1. To evaluate habitat preference
2. To find out the group compositions of herds in different habitats
3. To assess the diurnal and seasonal activities in different habitat
4. To determine the impact the availability of drinking water has on activity patterns
5. To document major food types.

2. STUDY AREA

2.1 General

The Sundarbans is the largest mangrove forest in the world. It is part of the delta of the river Ganges and is located in a unique bioclimatic zone in the coastal region of the Bay of Bengal (Map 1). It covers approximately 10,000 km^2. Part of which is in south-west Bangladesh (6017 km^2) and part in the south-eastern portion of the state of West Bengal in India (Hussain and Acharya, 1994). About 64% of this forest lies between latitudes 89°00' and 89°55' east and latitudes 21°30' and 22°30' north. Approximately two thirds of the forest is land and the remaining one third is water, in the form of rivers, canals and creeks of varying width. Bare ground, scrub grassland and clearings cover only 61 km^2 of the land portion (Chaffey *et. al.*, 1985).

The vegetated tidal lands of the Sundarbans are an important source of firewood, raw materials and fish for many people. It also functions as an essential habitat, nutrient producer, water purifier, nutrient and sediment trap, storm barrier, shore stabilizer, and has a high aesthetic attraction.

According to the Holdrige (1964) system, the Sundarbans may be classified as a tropical moist forest. The four main seasons are pre-monsoon (March-May), monsoon (June-September), post-monsoon (October-November) and the dry winter season (December-February). The coolest temperatures occur from December-January and the warmest at the end of the dry season during May-June.

The mean annual rainfall varies from about 2000 mm in the east to 1600 mm in the west. Eighty to eighty five percent of annual rainfall occurs during the monsoon season from May to September (Hussain and Acharya, 1994).

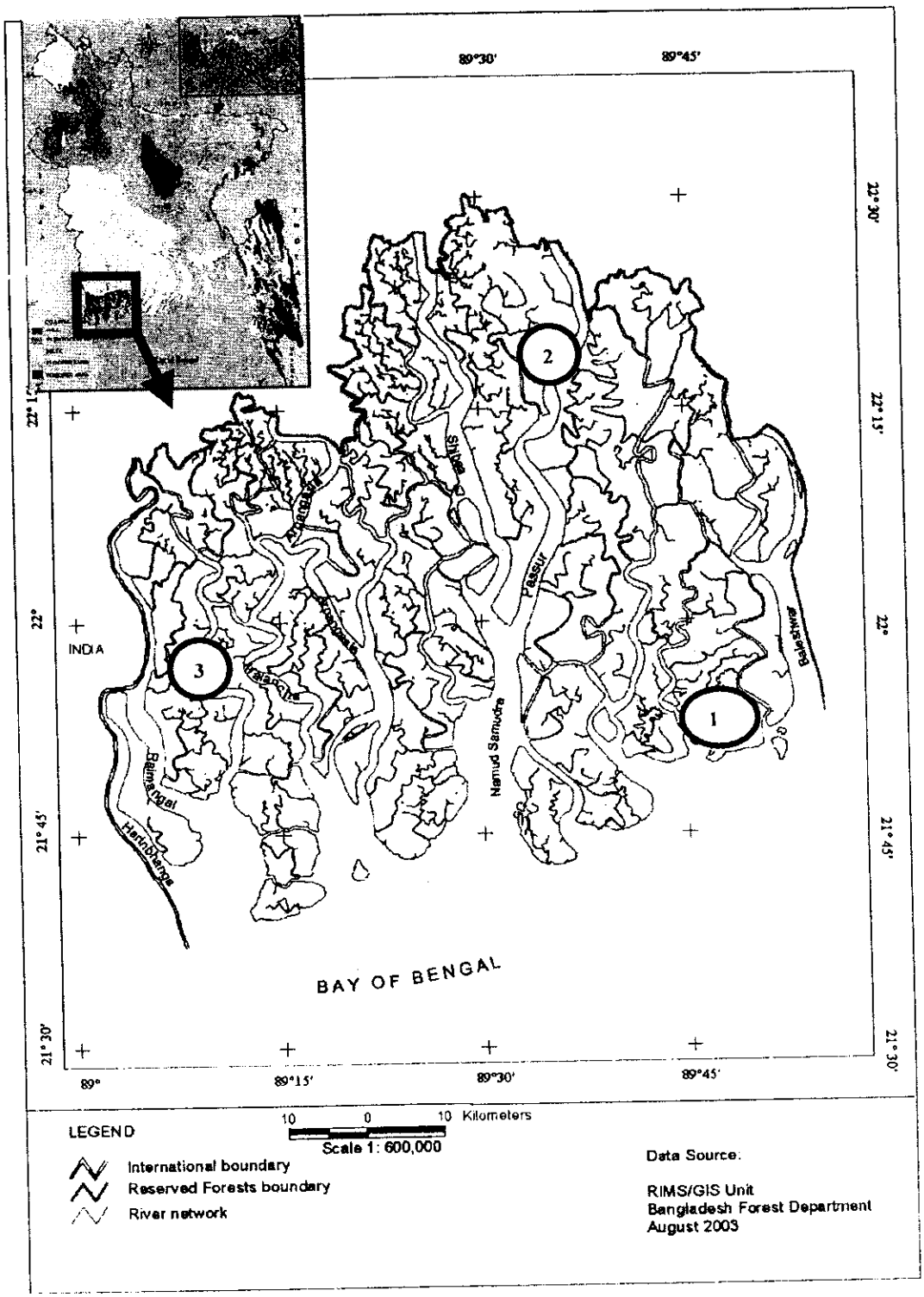
The Sundarbans has a complex and varied vegetation structure, and a total of 334 plant species have been recorded, of which at least 123 species occur in the Bangladesh Sundarbans (Hussain and Acharya, 1994). 10 forest types, namely, *pure*

Heritiera fomes, Heritiera fomes-Excoecaria agallocha, H. fomes and other species, *E. agallocha-H. fomes*, pure *E. agallocha, E. agallocha-Ceriops decandra, C. decandra-E. agallocha*, pure *C. decandra, Sonneratia apetala*, and minor species are recognized (Chaffey, *et.al.*, 1985). The dominant tree species of the fresh water zone is *Heritiera fomes* (Sundri), while *Excoecaria agallocha* (Gewa) is dominant in the moderately saline zone, and *Ceriops decandra* (Goran) in the highly saline zone. *Sonneratia apetala* (Keora) is usually found in the accreted mud flat areas of the Sundarbans. Most of the mangrove species are also characterized by viviparous germination, but in some cases providing anchorage with pencil-like roots developed before detachment of the seed from the parent body.

In view of recent studies the Bangladesh Sundarbans supports a diversity of biological resources, which includes at least 35 reptile species, over 290 species of birds, 42 species of mammals and 8 amphibian species. This represents 28-30% of the reptiles, 36-37% of the birds and 33-34% of the mammals found in Bangladesh (Hussain and Acharya, 1994). The Sundarbans are one of the largest remaining natural habitat of the renowned Bengal tiger (*Panthera tigris tigris*).

A great number of bird species has also been recorded from the Sundarbans forest. Among them are also endangered species such as Pallas's fish eagle, lesser adjutant, ruddy kingfisher, etc. (IUCN Red Book, 2000).

Indian one-horned rhino (*Rhinoceros unicornis*), Javan rhino (*Rhinoceros sondaicus*), wild buffalo (*Bubalus bubalis*), swamp deer (*Cervus duvauceli*), sambar (*Cervus unicolor*), hog deer (*Cervus porcinus*) and marsh crocodile (*Crocodilus palustris*) have become extinct from the Sundarbans (Hussain and Acharya, 1994).



Map 1. Map of the Sundarbans showing the three study sites (1. Katka-Kochihkali; 2. Jongra; 3. Notabeki)

2.2 Study sites

Mangrove forest ecosystems originally covered a vast area of coastal Bangladesh. These forests consist of brackish and fresh water marshes, inter tidal mud and sand flats, sand dunes with typical dune vegetation, open grasslands on sandy soils, and raised areas. These areas support a variety of terrestrial shrubs and trees.

After reconnaissance survey of the Sundarbans, three sites were selected for this study (Map1) . The study sites were:

i) Katka-Kochikhali in the Sundarbans East Sanctuary.
ii) Jongra under Chadpai range in the production zone.
iii) Notabeki in the Sundarbans West Sanctuary.

These study sites were selected because they cover all the major vegetation types of the Sundarbans that are used by spotted deer. The three sites are all in different salinity zones.

The number of study sites was kept small because of a constraint in time (since this study was only for six months) and funds.

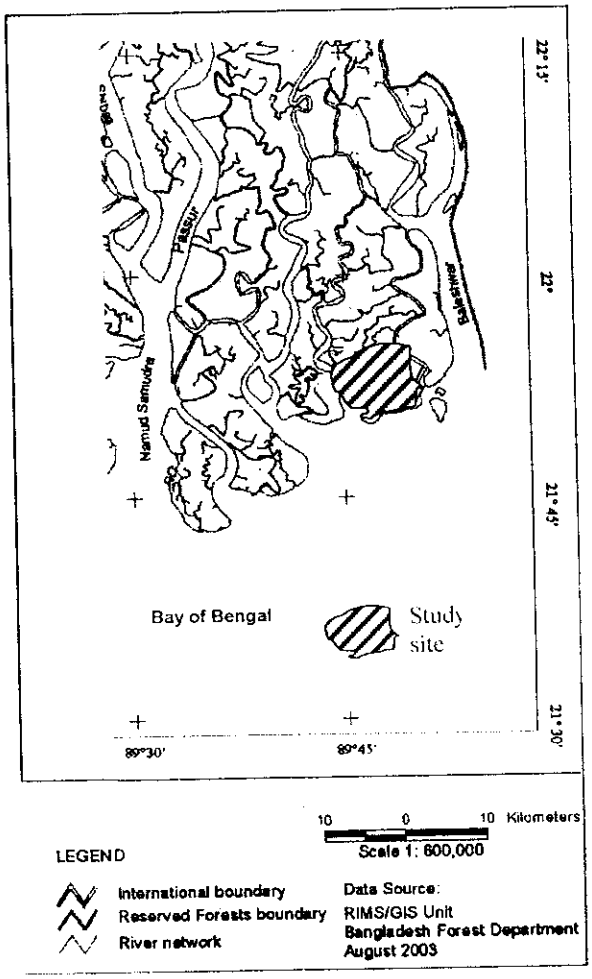
2.3.1 Katka-Kochikhali

The Katka-Kochikhali area is basically an island of around 20 km^2. It is surrounded by the Bay of Bengal in the south, Kochikhali and Jamtala Khal in the north, the Supoti River in the east and the Katka River in the west (Map 2). The area is composed mainly of forests, grassland and bushes. Forests cover about 50% of the area, grassland and open lands cover 20% and the remaining 30% consist of mudflats, canals, creeks and sea beach (Islam *et.al.*2001). This area is a part of Sundarbans East Wildlife Sanctuary and is located in the moderately saline zone area. The coastline of this island is irregular due to the formation of a number of tidal creeks. Katka-Kochikhali is located at the southeastern extreme of the Sundarbans.

The area consists of deep forests, grasslands, sea-beach, rivers, canals and creeks. This covers diverse habitat types, including a large grassland, which is an ideal place for the spotted deer and wild boar and also for the tigers due to the abundance of prey. There are eight man made water holes for drinking fresh water, which are also used by the animals.

The plant community *Nypa-Sonneratia-Heritiera-Excoecaria* covers most of this area. The natural vegetation of Katka-Kochikhali is dominated by halophytic tree species. Herbaceous climbers are also common; tiger fern, epiphytes and woody parasites mainly dominate the undergrowth.

Katka-Kochikhali is easily accessible on foot and was therefore finally chosen as a study site.



Map 2. Map of Katka-Kochikhali showing study sites (source: SBCP)

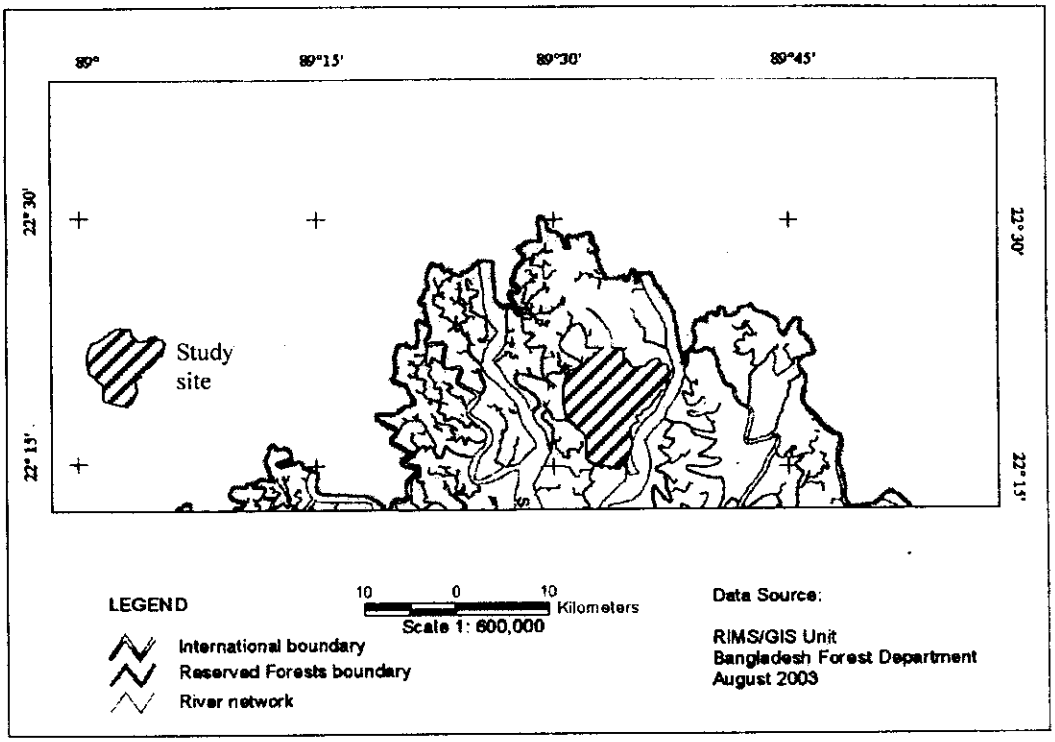
2.3.2 Jongra

This study site is located under Chadpai range (Map 3). The Passur River forms the boundary in the east. It is only 8 km south from Mongla port. Mara Passur and Karamjal forest offices are nearby.

The dominant plant species of this area are *Heritiera fomes*, *Excoecaria agallocha*, *Bruguiera gymnorrhiza*. Among the grass species *Cyperus exaltatus*, *Phragmites kankra*, *Myriostachya* sp. are common in this area. *Acrostichum aureum* (Tiger fern) is distributed in several patches near Andaria bhil. *Phoenix paludesa* (Hental), *Acanthus illicifolius* (Hargoza), *Pandanus odoratissimus* (Keya Katta) and *Nypa fruticans* (Golpatta) also occur here.

Portesia coarctata (Dhansi) is seen in the accreted mudflats of this area. This species of grass is associated with other types of grasses and trees such as *Cyperus*, *Sonneratia*, *Avicennia* and *Nypa*.

This study site is in the production zone, in a less saline area and is a little bit difficult to access due to the occurrence of thorny scrub species. The Andaria bhil is a large open area with grassland. This is also a good habitat for the spotted deer.



Map 3. Map of the Sundarbans showing study site in Jongra (Source: SBCP)

2.3.3 Notabeki

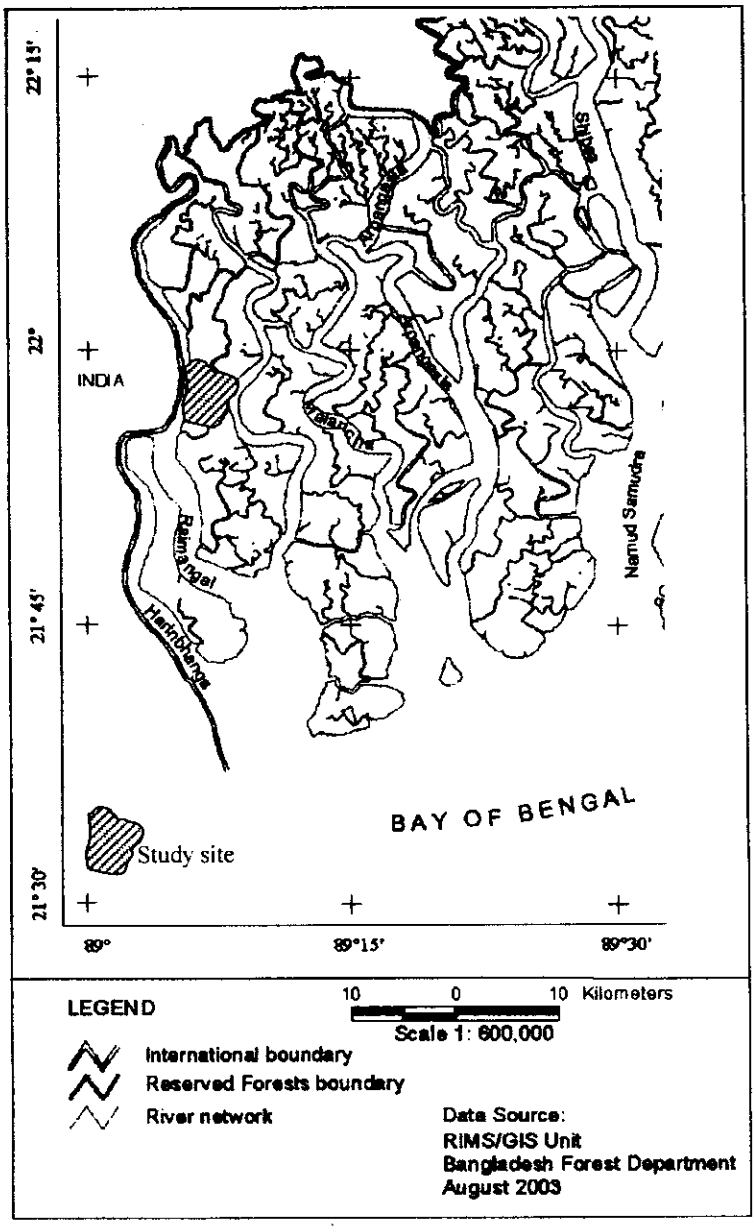
The study site, Notabeki is situated in the west sanctuary of the Sundarbans (Map 4). Two main rivers, the Raimongol and Jamuna are just to the west and east of the Notabeki study site. Notabeki is in a highly saline zone and is dominated by *Ceriops decandra* (Goran) and *Excoecaria agallocha* (Gewa). Besides these, Keora and Hental are also common.

The trees in this area are more or less bushy. Especially the Goran trees are very close to each other. Due to this reason it becomes more difficult to observe the animals. The canopy height of Goran is near about 3 meters high. The percentage of bare land in the plots is high, but canopy coverage is still higher.

In Notabeki the exposed ground (without any grass cover) has Keora, Goran, and Baen as the dominant tree species. In most cases, the percentage of undergrowth cover is about 5-8 percent. No regeneration was observed on this type of bare soil.

Portesia coarctata (Dhansi) is the main grass type of this area. It is found in the newly accreted mudflats. A small patch of grassland is found near Hilshamari khal and Kalkebari khal.

There is only one freshwater hole located near the forest office of Notabeki. But on the other side of the Notabeki study area, there is a water hole in an open space in the forest, with Keora, Goran and Baen trees nearby. The salinity of the pond is higher than the Jamuna River due to water evaporation. The salinity of the pond is 23.9°/$_{oo}$ and the temperature was 31°C, as measured on 25th March 2002. The pellets and tracks of the spotted deer are higher in this area than other portions of the Notabeki study area.



Map 4. Map of Notabeki showing study site (source: SBCP)

3. METHODS

3.1 General

The study was conducted between January 15, 2002 and July 15, 2002. Field work was conducted between February and June. Because of the bad weather condition in July, no field work was conducted. Twenty days of each month were spent in the field for data collection. The rest of the days were spent on arranging logistics from Khulna. Data was also partially analyzed during this period. A boat was continuously used during the six months of the field study. Time spent in different sites varied (Table1). A research associate with the help of one research assistant and several other field assistants continuously worked at the study sites collecting data using a pre-designed data sheet.

In the beginning of the study, Katka-Kochikhali was selected as study site. Katka-Kochikhali is perfect for direct visual observations. There are two big grasslands where the deer graze regularly. Less dense Keora forest is also present here and animal observation is easy. As a result most of the data on deer are collected from this site. In the later part of the study two other sites viz. Jongra (low saline zone) and Notabeki (high saline zone) were selected to compare with Katka-Kochikhali (medium saline zone). But very few data were collected from direct visual observation in the latter two sites. Direct observation in these sites was difficult because of the dense undergrowth, absence of large grasslands and more human disturbance. However all other activities for fulfilling the purposes of this study were conducted in these two sites similarly to that of Katka-Kochikhali (see Table 2).

Table.1 Time spent in different study sites in different months in the study area

Study sites	Time spent in the field (In week)															
	February				March				April				May			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Katka																
Jongra																
Notabeki																

Table.2 Activities recorded in different habitat in the study sites

Activities	Katka-Kochikhali	Jongra	Notabeki
Animal observation	✓	----	----
Group size and composition	✓	----	----
Track count	✓	✓	✓
Pellet count	✓	✓	✓
Vegetation study	✓	✓	✓
Dung analysis	✓	✓	✓
Rate of movement	✓	----	----

3.2 Habitat category and plant species

To find out the habitat preferences of spotted deer the habitats of each study site was initially assessed according to the following types:

1. Forest
2. Grassland
3. River bank/Levee
4. Sea beach

For more detailed information each habitat type was further categorized into several microhabitats according to the vegetation types of the sample plot, i.e. Keora forest, Gewa forest, Sundri forest, mixed forest etc. If the number of individuals of a species was more than 75% of the whole plot, the vegetation type was classified according to that particular tree species. If two species each covered over 40% of the plot then the vegetation type was recorded according to both of the two dominant tree species. If more than two species were found inside the sample plots and no species fulfilled the above criteria, then the vegetation type was recorded as mixed forest. In each case the habitat types were categorized according to this method.

The plots were considered as a symbol of all the habitat types. These plots were set randomly. Each plot was 200m² (20m x 10m) in size. The dominancy of the plant species inside the plots was estimated by eye and all the plant species of the plots were recorded. The following sample attributes were recorded from all the plots of the study sites:

- GPS position of the sample plots
- Vegetation types of the plots
- Soil composition of the plots
- Inundation by the tidal water
- % Tree cover of the plots
- % Herb cover of the plots
- % Shrub cover of the plots

3.3 Pellet count

Fuller (1991) developed the pellet count method to determine the habitat use pattern of spotted deer. Eisenberg and Lockhart (1972) and Dinerstein (1979) demonstrated the usefulness of this technique for estimating habitat use of deer in the dry scrub forest of Sri-Lanka and the tropical forests of Nepal. Indices for abundance of tiger-prey populations were derived from fecal pellet group counts on rectangular plots

(Eberhardt and Van Etten, 1956). Similar pellet count methods were applied in these three study sites for determining the habitat preference of spotted deer.

It is generally assumed that pellet density is correlated with the time spent at a certain location by spotted deer (SBCP IN no.34). The plots for pellet counts were established in different habitat types in the study sites. In this study, higher numbers of samples with smaller sample size were chosen, as this is more efficient for the determination of the statistical parameters of a distribution. The size of the plot samples, used for counting the number of pellets, was 200 m^2 (20m x 10m). The plots were selected randomly from all habitat types in all of the three study sites. These plots were then considered as being representative for the whole study site. The number of pellet groups inside each plot were counted whether fresh or old. When a pellet group was more than 50% inside the plot, it was counted. If the pellet group was less than or equal to 50% inside the plot, the pellet group was not recorded (SBCP IN no. 34). The same methodology has been used in different studies.

Table.3 Number of plots for pellet counts in each habitat in different study site

Study site	Forest	Grassland	Sea beach	River bank	Total
Katka-Kochikhali	32	21	7	2	62
Jongra	17	5	-	-	22
Notabeki	34	-	-	-	34
Total	83	26	7	2	118

3.4 Track count

Since defecation was very much associated with activity (mainly associated with resting) and distribution of pellets was observed to be very clustered, animal tracks were also counted besides conducting pellet counts in the study sites. Tracks are correlated with movement and they were calibrated by also using direct counting techniques in the plot sample areas when possible. The same plots that were used for the pellet counts were also used for track counts. From these plots the tracks of the spotted deer were counted by walking along one of the 20 m length sides and counting the tracks within a space 0.5m wide from the line. This was again repeated along one of the 10 m length sides of the plot. This was done to reduce the chance of

double counting, while still obtaining a sample for the whole plot. All the tracks were counted very cautiously. A track in the same strip was considered as one track if it went in one direction. The plots were established in all representative habitat types randomly.

In the grasslands the tracks of the spotted deer were very difficult to distinguish due to the dense ground cover. The tracks of the spotted deer were not imprinted in the soil or ground in the grass fields, so that tracks could not be counted in the grasslands during the study. The grasslands of Jongra were different than that of Katka-Kochikhali, and here five sample plots in grasslands were considered for track counts, as the visibility of the tracks of the spotted deer in the ground was better.

The tracks of spotted deer were also recorded around fresh water ponds following the pre-designed data sheet. The bank of the fresh water pond was more or less bare with a few grasses and some ground creepers. Only the banks surrounding the ponds within the study area were considered. These areas were also studied as the spotted deer usually visit the fresh water ponds to drink water.

Spotted deer also visit open sea beach areas to collect the leaves or fruits of various plants. These fruits or leaves usually come from different places during high tide. Among the three study sites, a long sea beach area in Katka-Kochikhali was used for track counting. The other two study sites did not have such sea beaches. Only seven plots were established on the sea beach in the Katka-Kochikhali study site. Sometimes the tracks and also the pellets were washed away by the high tide.

Table.4 Number of plots for track counts in each habitat in different study site

Study site	Forest	Grassland	Sea beach	River bank	Total
Katka-Kochikhali	32	-	7	2	41
Jongra	17	5	-	-	22
Notabeki	34	-	-	-	34
Total	83	5	7	2	97

3.5 Group size and composition

For the determination of group size and composition, only visual observation techniques were used in this study. GPS position, number, age and sex classes of observed deer groups were recorded on a pre-designed data sheet.

Individuals of one group will usually mix with other groups. In the study site especially in Katka-Kochikhali spotted deer have little competition for food or for shelter.

Data on group composition were recorded according to age-sex classes, which were previously categorized. The major age-sex classes of the spotted deer were adult male, adult female, juvenile and infant.

Table.5 Category of age-sex classes of the spotted deer during study period

Code	Type	Description
A.M	Adult male	Prominent antler and bigger in size as well as in body weight.
A.F	Adult female	Absence of antler and more than 1 year but bigger than the juvenile.
Ju.	Juvenile	More than 4 months but less than 1 year and smaller than the female and the male.
Inf.	Infant	Less than 3-4 months of age and has a close relationship with its mother.

The observations were conducted in different habitats, i.e. forests, grasslands, riverbanks and sea beaches in Katka-Kochikhali. Among the four types of habitat, the grassland was the most convenient place for direct observation of the animals. Age-sex classes were not recorded from Jongra and Notabeki due to the difficulty in applying the methodology needed to do this properly.

3.6 Diurnal activity and habitat utilization

For recording the diurnal activities of the spotted deer the scan sampling method was used. The data were collected at 10-minute intervals. An interval of 10-minutes ensured that each scan was discrete from the previous one. It is an essential requirement to satisfy conditions for statistical analysis. The behaviour of one individual during each scan was recorded as one observation. In scan sampling, the behaviour of all individuals is done over a short time period; thus the records approach a simultaneous sample for all individuals in the group. Data was thus obtained on the time distribution of behavioural activities in the whole social group. Data were also obtained on the behavioural synchrony of the group. The observations started at 6 a.m. and ended at 5 p.m. in all representative habitats. Data was collected only for Katka-Kochikali.

To determine the habitat utilization of spotted deer, several methods were applied. Either the direct observation method or the scanning method was applied for animal observations, group size estimates and composition records, as well as determining the congregation of deer around the fresh water holes in Katka-Kochikhali. In Katka-Kochikhali, there were 2 big grasslands and a less dense Keora forest with no undergrowth. Because of this it was easy to observe the spotted deer and their activities. Direct visual observations were only done in Katka-Kochikhali.

In Notabeki the direct observation method was attempted and a mobile observation tower was used in more or less open areas. However, no deer were observed while the observation tower was being used and due to bad weather and time limitations it was not possible to continue this aspect of the study.

Table 6. Total numbers of scans, scan time and individual in different habitat

Habitat	No. of scan	Scan time (Hours)	No. of individual scanning
Grassland	346	57.66	2748
Keora	114	19	1234
River Bank/Levee	145	24.16	157
Sea Beach	80	13.33	0
Total	685	114.16	4139

Eight types of activities of the spotted deer were recorded in this study. The activities were as follows:

a) Grazing/Browsing: When the spotted deer eats any type of grass as food then it was recorded as grazing, but if it eats the leaves of the trees, it was recorded as browsing.
b) Standing
c) Walking
d) Resting
e) Running
f) Drinking
g) Preaching: The word preaching is termed by Brander (1923) and consists of a male standing on his hind legs in order to feed on leaves or exposed twigs of a low-hanging. It requires a tree located at the edge of an open area or a solitary tree in the open and have a low-hanging branch 5.5 to 6 feet off the ground.
h) Chasing: When two males fight each other either for courtship with a female or reducing the competition for food or shelter or for establishing dominance over the group.

3.7 Food preference

To study the food items selected by spotted deer the direct observation technique was implemented. When the deer was grazing or browsing, then it was noted which species and which part of the plant they took as food. A powerful binocular was used for this purpose. Sometimes, several leaves of different plant species with their branches were retrieved to ensure which types of plant species they had taken as their food.

Unknown species were identified with the help of an expert from the National Herbarium. Firstly, the plant species were collected from the study site. Then the collected plant parts were preserved in herbarium sheets. Finally it was sent to National Herbarium for identification.

4. RESULTS

4.1 Habitat types

The habitats of spotted deer were divided into four categories initially. The habitat types were 1) Forest, 2) Grassland, 3) Riverbank and 4) Sea beach. On the basis of the vegetation in the sample plot the habitat types were further classified as the following table.

Table7. Different vegetation types in different study sites

Study area	Major habitat types	Vegetation types	Major species
Katka-Kochikhali	Forest	Keora	*Sonneratia apetala*
		Gewa	*Excoecaria agallocha*
		Goran	*Ceriops decandra*
		Sundri	*Heritiera fomes*
		Sundri-Gewa	*Heritiera fomes* - *Excoecaria agallocha*
		Mixed (Ge-Ke-Su-Ba)	*Excoecaria agallocha, Sonneratia apetala, Heritiera fomes, Avecennia officinalis*
	Grassland	Beach wall	*Imperata cylindrica, Cynodon dactylon*
		Back swamp	*Imperata cylindrica, Cynodon dactylon, Cyperus exaltatus, Fimbristylis sp.*
		Accretion land grassland	*Cyperus exaltatus*
	River Bank/Levee		
	Sea Beach	-	-
Jongra	Forest	Sundri-Gewa	*Heritiera fomes* - *Excoecaria agallocha*
		Kankra	*Bruguiera gymnorrhiza*
		Sundri	*Heritiera fomes*
		Tamarix	*Tamarix*

		Mixed	*Heritiera fomes - Excoecaria agallocha, Phoenix paludosa, Pandanus foetidus, Acanthus ilicifolius, Cynometra ramiflora*
	Grassland	*Acrostichum*	*Acrostichum*
		Portesia	*Portesia*
		Cyperus-Phragmites	*Cyperus-Phragmites*
		Acanthus-Pandanus	*Acanthus, Pandanus*
		Phragmites	*Phragmites*
		Cyperus	*Cyperus*
Notabeki	**Forest**	Goran-Gewa	*Ceriops decandra-Excoecaria agallocha*
		Gewa-Goran	*Excoecaria agallocha - Ceriops decandra*
		Goran	*Ceriops decandra*

A total of 62 plots had been established randomly in Katka-Kochikhali study site. On the basis of dominant tree species found in the plots the forest habitat was divided into six types of habitats (Table7). In Katka-Kochikhali the grassland was classified into three types on the basis of topological condition (Table7). As the spotted deer frequently visit the riverbank and sea beach these were considered as another two habitat types.

In Jongra, a total of 23 plots were established among which 15 plots in the forest and 8 in the grassland. In Notabeki, all 34 plots are in the forest. The forest of Notabeki was divided into three categories according to Goran-Gewa, Gewa-Goran and Goran types. All plots were established to determine the utilization of habitats by spotted deer, through track and pellet counting in the field.

Table. 8 Number of plots in major habitat types in different study sites

Study site	Number of plots in major habitat types				Total
	Forest	Grassland	Riverbank/Levee	Sea beach	
Katka-Kochikhali	32	21	2	7	62
Jongra	15	8	-	-	23
Notabeki	34	-	-	-	34
Total	81	29	2	7	119

4.2 Track count

4.2.1 Katka-Kochikhali

A total of 98 plots were established in various habitat types at the different study sites for determining the habitat preferences of spotted deer. These plots were used for track counts of spotted deer. The mean of tracks per plot at Katka-Kochikhali, Jongra and Notabeki were 114.02 (sd± 78.99), 25.69 (sd± 29.09) and 53.94 (sd± 25.55) respectively (Table 9).

On average, track densities are higher on the riverbanks than in forest and other habitats (Fig.1). It shows that the deer use this habitat frequently. On the sea beach the number of deer tracks (23.71/plot, sd±23.71) are very low, which indicates that this is not a habitat that the deer will use extensively.

In forested areas of Katka-Kochikhali, the maximum number of tracks was found in Keora forest (200.6/plot, sd± 38.43; Fig. 2) and minimum are in Sundri-Gewa forest (11/plot) (Table 10). In order of number of tracks found, the sequence is, Keora forest, Gewa dominated forest, Goran, Mixed forests, Sundri, and Sundri-Gewa (Table 10).

Table 9. Tracks/plot in different study sites of Sundarbans

Study site	Number of tracks/plot				Number of plots
	Maximum	Minimum	Mean	sd±	
Katka-Kochikhali	256	0	114.02	78.99	41
Jongra	26	0	25.69	29.09	23
Notabeki	125	8	53.94	25.55	34

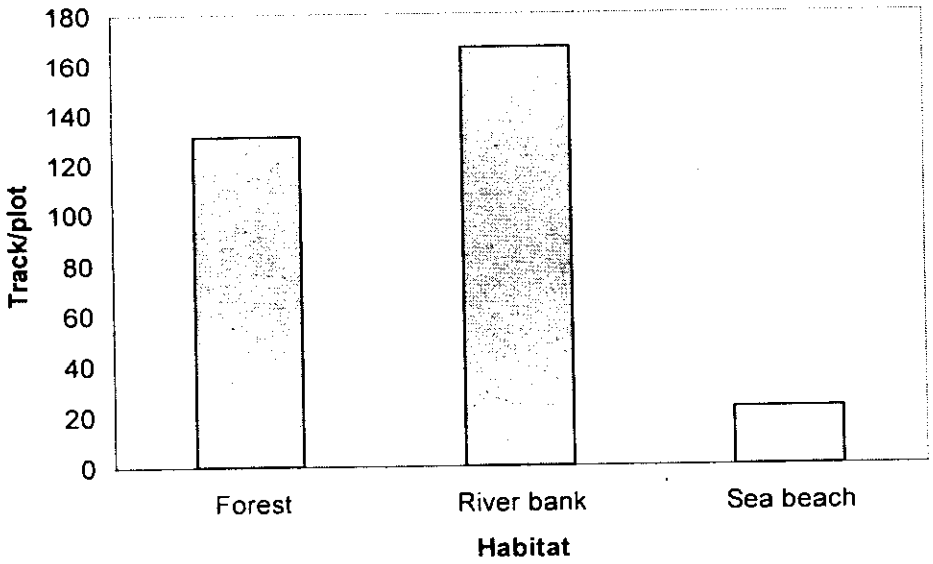


Fig. 1. Overall track/plot in different habitat of Katka-Kachikhali

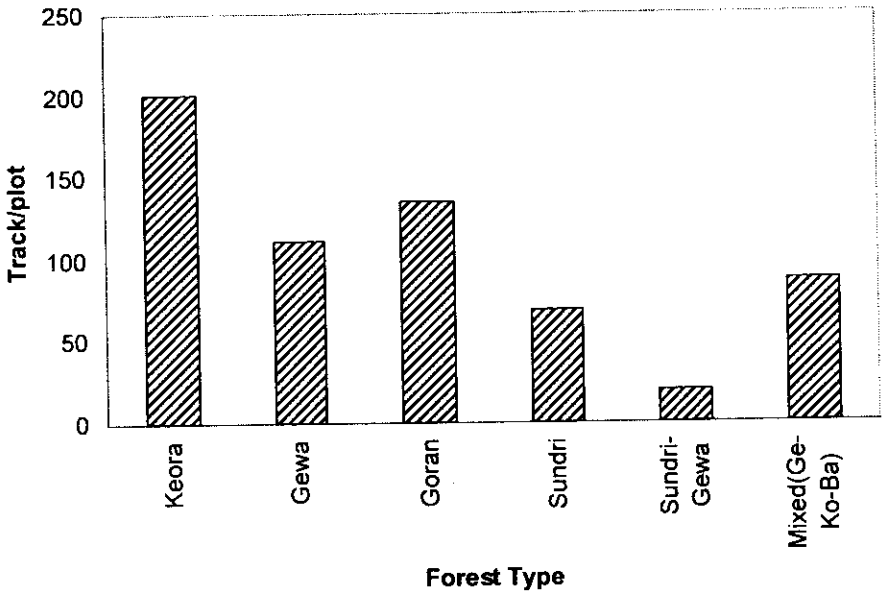


Fig.2. Number of track/plot in different forest types in Katka-KachiKhali

Spotted deer prefer Keora leaves and fruits as their food item, which are plentiful at the Katka-Kochikhali study site. At Katka, more than 80% of the trees found in each forest patch are Keora. It may be a factor that influences the deer to concentrate in that particular habitat. This forest has no undergrowth and the pneumatophores of the Keora trees are not very prominent, which can otherwise make it difficult for deer to move around. This also improves visibility and the deer are relatively safe from attacks by tigers. Besides in the Keora forest there are two big fresh water holes where they can get water to drink. Though the Keora forest is not large in size, the combination of the factors mentioned above likely influences the deer to concentrate in this particular habitat.

Table10. Track counted from Katka-Kochikhali area

Habitat	Number of track/plot				Number of plots
	Maximum	Minimum	Mean	Sd±	
Keora	258	149	200.55	38.43	9
Gewa	212	15	115.18	55.40	16
Goran	-	-	119	-	1
Sundri	-	-	58	-	1
Sundri-Gewa	-	-	11	-	1
Mixed (Ge-Ke-Su-Ba)	183	2	89	76.05	4
Total in forest	**258**	**2**	**131**	**69.48**	**32**
River bank	**172**	**162**	**167**	**7.07**	**2**
Sea beach	**142**	**0**	**23.71**	**52.24**	**7**
Total	**258**	**0**	**114.43**	**77.14**	**41**

Spotted deer visit the riverbank habitat twice daily. This riverbank is adjacent to the Keora forest and a few Keora trees are also present on the banks of the river. Even some feeding materials are washed on to the riverbank during high tide and the spotted deer consume these during low tide. Track densities were also high in Gewa and Goran forest. Deer did not feed on Gewa and Goran leaves in Kotka-Kochikali but did feed on gewa leaves in Notabeki. Feeding on gewa leaves was also recorded in another study (Siddiqi, 1999). Gewa forest is also not very dense as the undergrowth is sparse and Gewa itself has no pneumatophores. The Gewa forest is adjacent to the grassland in Katka-Kochikali, and deer use this forest to take rests in the shade the

forest provides. They also browse inside the forest on Keora leaves. The deer mostly avoid Sundri habitat, as it seems to be difficult for them to move through the pneumatophores of the Sundri trees. This type of forest possesses more undergrowth, and the density is higher. It is mainly a mixed type forest but the dominant plant species is Sundri. This habitat type is adjacent to the grassland along the edge of the forest.

During the study, three sites have been studied to determine the habitat utilization of spotted deer. In the study sites the pneumatophore of the mangrove species has different shapes and heights. Normally the presence of the deer has a correlation with the height of the pneumatophore. The spotted deer usually do not prefer habitats in which the pneumatophores are particularly big as is the case in Sundri forest types. The pneumatophore acts as obstacles during their movement. This also prevents them from escaping quickly from the attack of a predator.

The number of pellets and the tracks of the spotted deer are found less where the pneumatophores are larger. Sometimes the density of the pneumatophores also has this effect on the presence of spotted deer. The spotted deer usually prefer the open areas with few pneumataphores moving through. Only a moderate number of tracks and pellets of deer were found in some of the plots where the height and the density of the pneumatophores was high.

Spotted deer visit the sea beach in limited numbers. They only come here to consume food materials, are washed on to the shore during high.

4.2.2 Jongra

The forest types of Jongra are different from the Katka-Kochikhali study site. The density of the forest is higher and Sundri trees dominate in this forest. Gewa is also present in this study site. Track density in this area is ¼ of that found in Katka-Kochikhali. A total of 23 plots were established for determining habitat preferences of spotted deer in Jongra. The mean number of tracks per plot at Jongra was 25.69 (sd± 29.09) (Table 11). Among the forested areas of Jongra, the maximum density of

tracks was found in Kankra forest (120/plot; Fig.3). Kankra forest is less dense and provides shade and so these plots were highly used by the spotted deer as a resting place. There was little undergrowth and no pneumatophores and therefore these areas are easily accessible for the spotted deer. No fresh water hole was found in Jongra. In the case of grasslands, the highest number of tracks was found in *Cyperus* (68/plot, sd± 38.66) dominated plots. But in grasslands with *Acanthus* and *Pandanus* no deer tracks were found, because of their bushy and thorny characteristics. There are some open lands, which normally are submerged during the monsoon. These flooded areas are generally known as 'beels'.

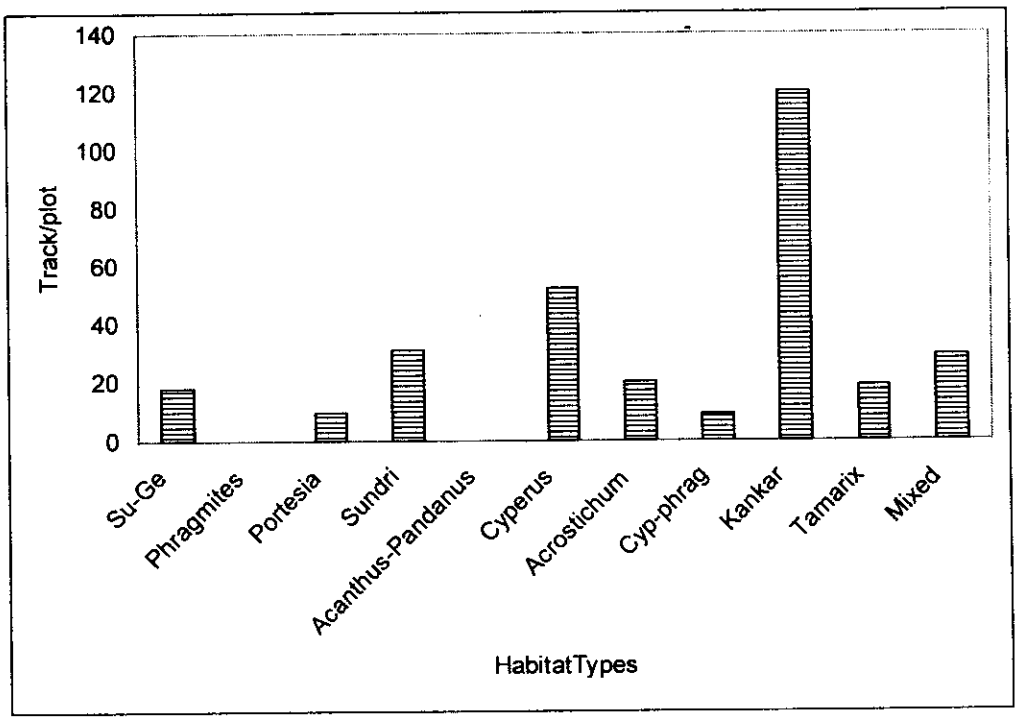


Fig.3. Number of track/plot in different habitat types of Jongra

Table11. Tracks counted from Jongra

Habitat	Vegetation types	Number of tracks/plot				Number of plots
		Maximum	Minimum	Mean	sd±	
Forest	Sundri-Gewa	19	2	9.33	8.73	3
	Sundri	36	7	23.25	12.01	4
	Kankra	-	-	120	-	1
	Tamarix	-	-	14	-	1
	Mixed	67	0	32.66	27.45	6
	Total forest	**120**	**9**	**29.4**	**32.17**	**15**
Grassland	Phragmites	-	-	0	-	1
	Portesia	-	-	7	-	1
	Cyperus	68	22	38.66	25.48	3
	Cyperus-Phrag	-	-	3	-	1
	Acanthus-Pandanus	-	-	0	-	1
	Acrostichum	-	-	14	-	1
	Total grassland	**68**	**22**	**17.5**	**22.64**	**8**
Total		68	22	25.69	29.09	23

4.2.3 Notabeki

Goran and Gewa trees are the dominant tree species in this study site. The track density is near about half that of Katka-Kochikhali, yet two times higher than that of Jongra. There is no grassland where the deer can graze. Only one fresh water pond is located just behind the forest office, enclosed by fences. It is difficult for the deer to drink there. Goran forest is denser than Gewa dominated forest. On the other hand, the deer sometimes take gewa leaves as food, but not Goran leaves. This is likely to be why in Gewa-dominated forest the track density (mean 59.66, sd± 14.66) is higher than in Goran dominated forest (mean 55.61, sd± 26.20; Fig.4). The lowest track densities in Notabeki were found in pure Goran forest (Table 12).

Goran forest is bushy with dense vegetation, which makes it very difficult for the deer to move and therefore they can be easily attacked by predators. Track density is also less in Goran forest due to a scarcity of food items. In Notabeki, the deer eat Gewa leaves but this habit is not found in Katka-Kochikhali. They also take the leaves of

Passur, Baen, Amur, Dhundhol and also Keora. Gewa dominated forest is more open than Goran forest and is therefore more accessible for deer and visibility is improved.

Table12. Track counted from Notabeki area

Habitat	Number of tracks/plot				Number of plots
	Maximum	Minimum	Mean	sd±	
Goran-Gewa	125	8	55.61	26.20	26
Gewa-Goran	76	37	59.66	14.66	6
Goran	17	13	15	2.82	2
Total	125	8	53.94	25.55	34

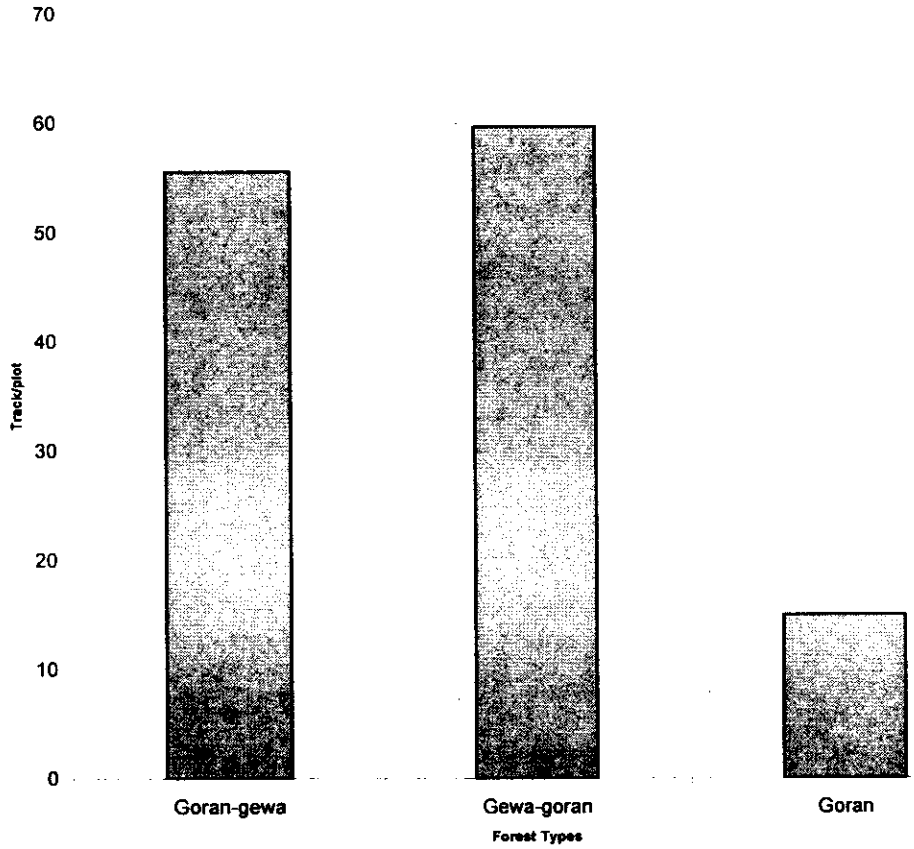


Fig.4. Track count in different forests of Notabeki study area

4.3 Pellet count

4.3.1 Katka-Kochikhali

A total of 119 plots were established for pellet counts in order to further determine the habitat preferences of spotted deer. The mean of pellets per plot at Katka-Kochikhali, Jongra and Notabeki were 12.33 (sd± 14.86), 2.65 (sd± 3.83) and 0.5 (sd± 0.99) respectively (Table 13). In Katka-Kochikhali, the maximum number of pellets were found in grasslands (25.14/plot, sd± 17.62) and the minimum number were on riverbanks and the sea beach (0/plot) (Table 14).

Table13. Pellets/plot in different study sites

Study site	Number of pellet/plot				Number of plots
	Maximum	Minimum	Mean	sd±	
Katka-Kochikhali	65	0	12.33	14.86	62
Jongra	13	0	2.65	3.83	23
Notabeki	4	0	0.5	0.99	34
Total					119

In the study plots at Katka, Keora trees comprise more than 80% of the total area. As their food item, the deer prefer the Keora leaves and fruits, and even the young twigs. This forest has no undergrowth, which can otherwise make it difficult for deer to move around. This is also a less dense forest and visiblility is better, so deer can easily see any predators. The spotted deer uses this habitat much for resting.

Deer pellets are found even more in the grassland (25.14/plot, sd± 17.62) than in the Keora forest (22.22/plot, sd± 6.72). On the sea beach and riverbanks, no pellets were found, because these areas are regularly inundated at high tide and all pellet groups are washed away.

Table14. Pellet counted from Katka-Kochikhali area

Habitat	Number of pellet/plot				Number of plots
	Maximum	Minimum	Mean	sd±	
Keora	32	12	22.22	6.72	9
Gewa	26	0	6.93	7.26	16
Goran	-	-	15		1
Sundri	-	-	3	-	1
Sundri-Gewa	-	-	3	-	1
Mixed (Ge-Ke-Su-Ba)	12	0	7.75	5.31	4
River bank	0	0	0	0	2
Sea beach	0	0	0	0	7
Grassland	65	0	25.14	17.62	21
Total	**65**	**0**	**14.37**	**14.94**	**62**

4.3.2 Jongra

The forest types of Jongra are different from the Katka-Kochikhali and Notabeki study sites. The forest is denser than at the other two sites. The dominant tree species is Sundri. Gewa is also present in this study site. Pellet density in this area is half that of Katka-Kochikhali. The maximum density of pellets is found in *Cyperus* type of grassland (13/plot) (Table 15).

In grassland, pellet densities are found more often in *Cyperus* grassland, but in *Acanthus* and *Pandanus* grassland, with bushy and thorny characteristics, no deer pellets were found. 'Beel' areas had a low number of pellets.

Table15. Pellet counted from Jongra

Habitat	Vegetation types	Number of pellet/plot				Number of plots
		Maximum	Minimum	Mean	Sd±	
Forest	Sundri-Gewa	2	0	0.66	1.15	3
	Sundri	6	0	3	2.44	4
	Kankra	-	-	12	-	1
	Tamarix	-	-	6	-	1
	Mixed	7	0	1.83	2.99	6
	Total forest	**12**	**0**	**2.87**	**3.58**	**15**
Grassland	*Phragmites*	-	-	0	-	1
	Portesia	-	-	0	-	1
	Cyperus	13	2	6	6.08	3
	Cyperus-Phragmites	-	-	0	-	1
	Acanthus-Pandanus	-	-	0	-	1
	Acrostichum	-	-	0	-	1
	Total grassland	**13**	**0**	**2.25**	**4.49**	**9**
Total		**13**	**0**	**2.65**	**3.83**	**23**

4.3.3 Notabeki

This study site is dominated by Goran and Gewa trees. The mean pellet density was 0.5 / plot (sd±0.99) (Table 16). There are no grasslands here where the deer can graze. There is only one fresh water pond, which is enclosed by fences, so it is difficult for the deer to drink there. In Gewa-Goran dominated forest the pellet density (mean 0.66, sd± 1.21) was higher than Goran-Gewa dominated forest (mean 0.5, sd± 0.98). But the pellet density was lowest in areas of pure Goran forest (Table 16).

Table 16. Pellet counted from Notabeki

Habitat	Number of pellets/plot				Number of plots
	Maximum	Minimum	Mean	sd±	
Goran-Gewa	4	0	0.5	0.98	26
Gewa-Goran	3	0	0.66	1.21	6
Goran	0	0	0	0	2
Total	**4**	**0**	**0.5**	**0.99**	**34**

4.4 Comparative study

The tracks and pellet density are highest in Katka-Kochikhali compared to the other sites (Fig.5). Interestingly, plots in Notabeki had more tracks than Jongra, but roughly the same number of pellets.

In Katka-Kochikhali, the spotted deer graze regularly in the two big grasslands. These areas mainly composed of *Imperata cylindrica* (Sungrass) species, which is the principal food item of the deer in such grasslands. They can take rest in the shady places during strong sunlight. There are mixed forests, which are normally open and less dense, on both sides of the grassland. Katka-Kochikhali area has eight fresh water holes where the deer drink regularly. In Katka-Kochikhali, the forest is dominated by a large number of Keora tree species. In the forest Keora is a major food type consumed by the deer of which the leaves and fruits are eaten.

Among the three sites number of pellets per plot did not much but the number of tracks per plot varied significantly. Tracks of deer are related to movement, while

pellets are related to resting. In Katka-Kachikhali, there are large grasslands with water bodies surrounded by Keora and other forest. This habitat is preferred by deer and can support a large deer population, hence the number of tracks per plot are higher here than in the other two sites.

In Jongra, waterlogged and marshy areas restricted the area of suitable deer habitats and hence movement was also restricted. The preferred food species are less abundant and therefore seems to support a lower deer population than in the other sites.

In the study site of Notabeki deer only use the bare ground (ground without grass cover) for browsing from trees and for moving between different habitats. Since they never use this open area for resting, defecation is less frequent and the number of pellets are lower than the number of tracks. Though Notabeki is in a higher salinity zone, it supports more deer than Jongra, because here the deer are not confined, as they have a larger area to move in, and there is therefore also more food available.

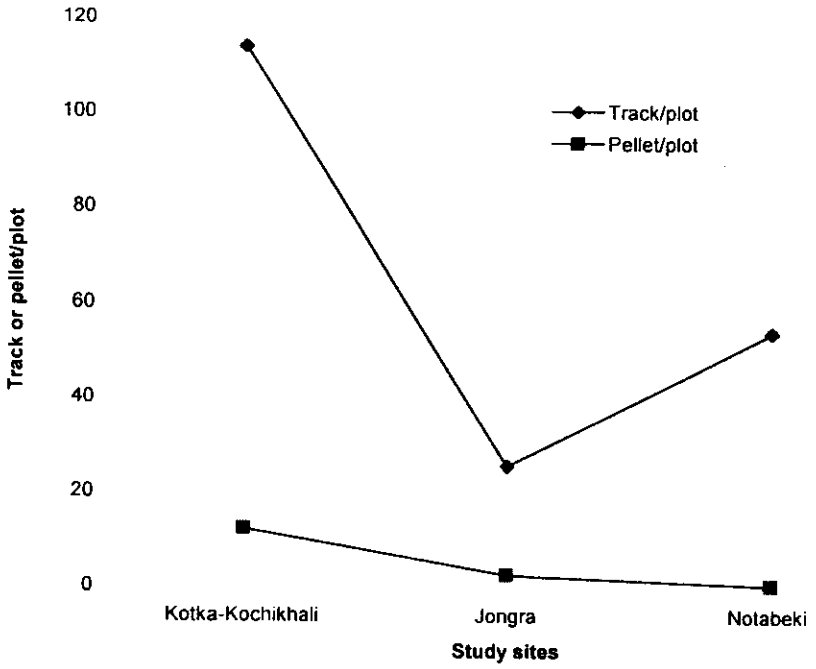


Fig.5. Comparative study of track and pellet count of the study area

4.5 Diurnal activities of the spotted deer

A total of 685 scans were done in Katka-Kochikhali. The scan time was 114 hours and 10 minutes. During the study period, 4133 individuals were scanned at Katka-Kochikhali (889 male, 2471 female, 665 juvenile and 108 infants). In Notabeki a total of 19 hours 40 minutes were spent on the observation platform, but no individuals were scanned due to human disturbance and bad weather and finally because of time limitations.

Table 17. Total number of scans and scan time in the study areas

Study site	Habitat	Number of scan	Scan time (hrs)
Katka-Kochikhali	Grassland	346	57.66
	Keora	114	19
	River Bank/Levee	145	24.16
	Sea Beach	80	13.33
Notabeki	Open Forest	118	19.66
Total		803	133.82

Time spent in different activities by different age-sex group varies (Fig.6). They spent more time in grazing than other activities (Fig.7). Of all feeding activities that were recorded, 47% were from the grassland and 35% in the forest, while the rest took place in other habitats. When the deer visited grasslands, most of the time (60%) is spent on feeding (Table 19). Females were found to be more involved than other individuals including infants in feeding (Fig.8). Spotted deer were found walking and standing directly after feeding, and these activities are highest in forests and riverbanks respectively. Preaching and chasing were found only in the case of male deer, but at low levels (0.45% and 0.45%). Drinking was only observed for females and juveniles in this study (Table 18). Infants were found to run more than other individuals.

Table 18. Individuals in age-sex classes involved in different activities

Activities	Male (%)	Female (%)	Juvenile (%)	Infant (%)	Total (%)
Browsing/grazing	40.49	60.54	51.28	28.70	53.91
Walking	26.54	19.42	26.16	29.63	22.31
Standing	21.82	15.22	15.94	24.07	16.98
Resting	9.22	4.21	1.50	5.56	4.89
Running	1.01	0.45	4.81	12.04	1.57
Drinking	0	0.16	0.30	0	0.14
Preaching	0.45	0	0	0	0.10
Chasing	0.45	0	0	0	0.10

Table 19. Comparison of the different activities of spotted deer in different habitat

Activities	Number of individuals (%)		
	Grassland	Forest	River bank
Browsing/grazing	60.19	44.00	22.98
Walking	19.57	29.33	14.91
Standing	16.36	16.77	29.19
Resting	2.26	7.45	29.81
Running	1.24	2.43	0.62
Drinking	0.22	0	0
Preaching	0	0	2.48
Chasing	0.14	0	0

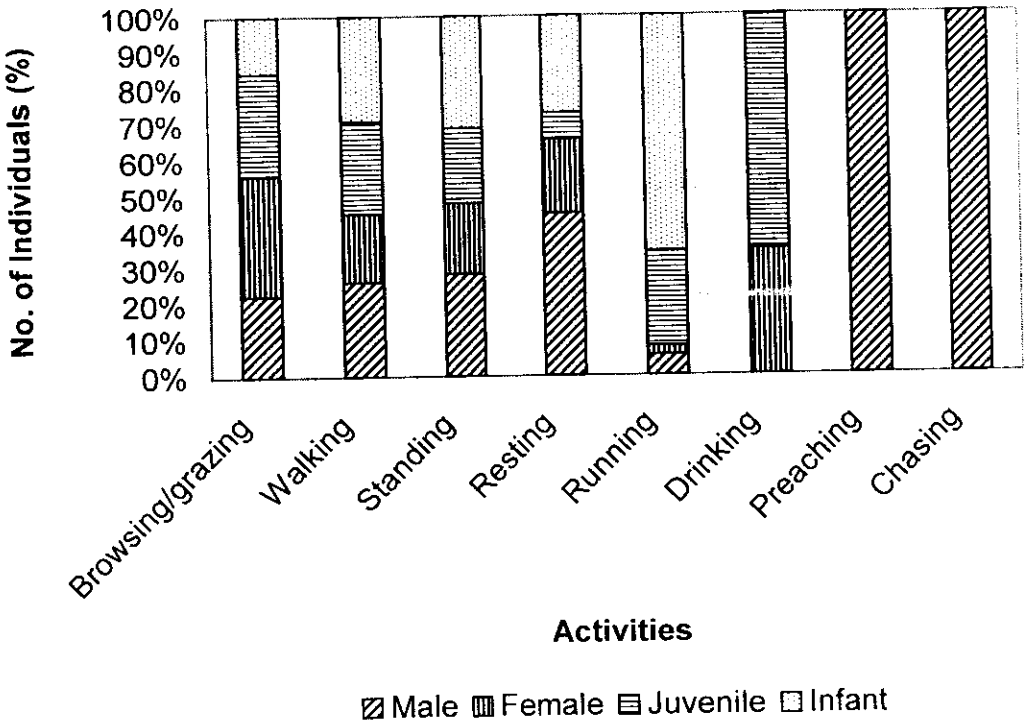


Fig.6. Activity pattern of different age sex classes

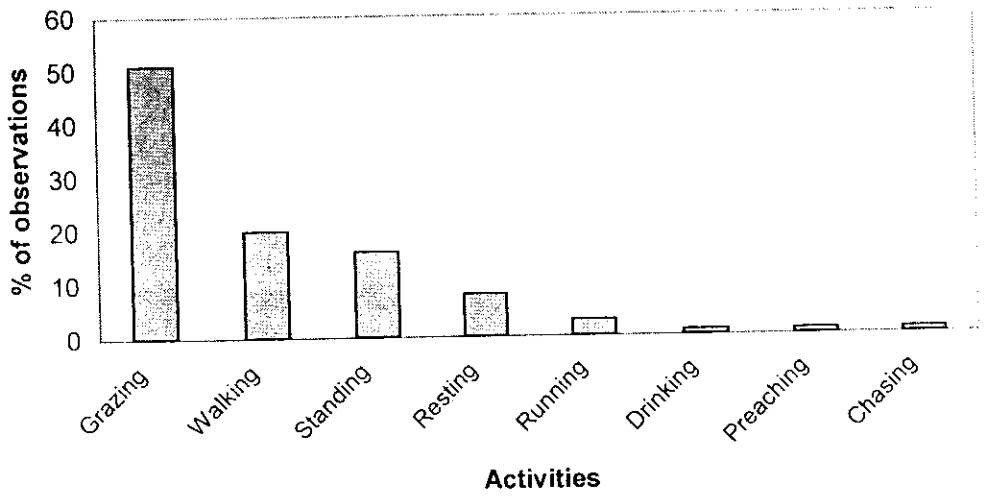


Fig.7. Overall activities of the spotted deer in the study area

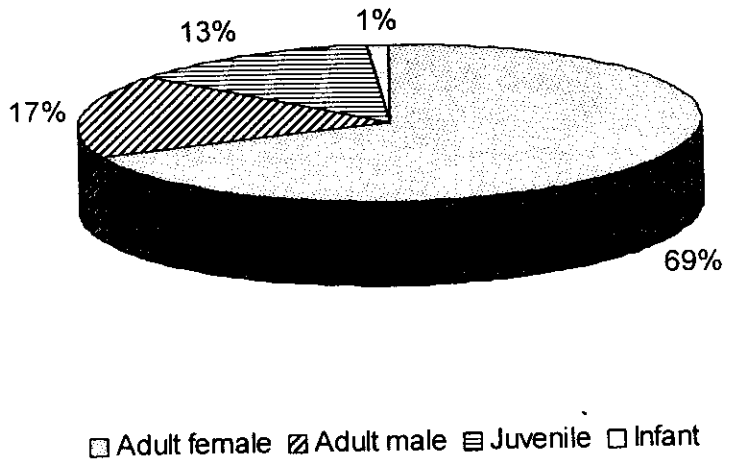


Fig.8. Proportion of different age-sex classes involved in grazing in grass land

4.6 Group size and composition

In the field, group size and composition was determined through direct visual counting. In this study four categories of individuals were considered, viz. adult male, adult female, juvenile and infant. The adult male is distinguished by the presence of prominent antlers and is bigger in size and body weight, whereas adult females have no antlers and are smaller in body size than the adult male. Juveniles were classified according to size. The size of an individual is determined by eye estimation with the help of 20 x 50 m binoculars. Finally an infant is determined by the closeness with its mother, and by its size.

The individuals of a group are always mixing with other individuals of another group. It is therefore very difficult to identify any particular group of spotted deer. Normally a group will consist of all four categories, i.e. the adult male, adult female, juvenile and infant (Fig.9).

The individuals of a group mixed with other members of the other group while grazing, moving, walking and resting. Group sizes change in order to avoid the attacks of predators and also to reduce the competition for food. If less food is available usually the members of a group will split in to smaller groups. But in Katka-Kochikhali, this fluctuation is found less due to huge food availability. For this reason, two or more groups of spotted deer usually seemed to be concentrated in one large group. The number of individuals in a group will depend on the availability of food, water and shade for resting.

To determine the group size and composition of the spotted deer at Katka-Kochikhali, 4 types of habitats were considered. This could only be done in Katka-Kochikali due to the relative openness of the vegetation. Without visual ability, no group size can be determined. The habitat types are forest, grassland, river bank/levee and sea beach. A total of 164 groups of spotted deer were counted during the study period. Among these groups, 42 were in Keora forests, 87 in grasslands, 34 in riverbanks/levees, and 1 group of spotted deer was observed on the sea beach of Katka-Kochikhali during the study period.

In Katka-Kochikhali, the largest group was found in May, consisting of 103 individuals in the grassland. The minimum number of individuals in a group was 3 and this was also found in the grassland. Normally, the number of individuals in a group is higher in open grassland (mean = 16.88, sd± 13.04; Fig.10) than in Keora forest (max = 36, min = 4, mean = 15.55, sd± 7.78) (Table 20). The mean of the spotted deer at riverbank was 12.82 and sd± 10.90 (maximum 63 and minimum 4).

Only one group of the spotted deer was observed in the sea beach consisting of 4 adult male during this study period. Some feeding materials come near the shore during high tide, for which the spotted deer come to eat them. However, deer were not often found to visit the sea beach.

Table 20. Number of individuals of the spotted deer per group at Katka-Kochikhali

Habitat	Maximum	Minimum	Mean	Sd±	Number of groups
Forest	36	4	15.55	7.78	42
Grassland	103	3	16.88	13.04	87
Sea beach	-	-	4	-	1
River bank	63	4	12.82	10.90	34
Total	103	3	15.62	11.50	164

Table 21. Individual/group of the spotted deer in the study sites

Age-sex category	Maximum	Minimum	Mean	Sd±	Number of herds
Male	21	0	2.76	3.01	164
Female	39	0	7.32	5.94	164
Juvenile/infant	43	0	5.54	5.43	164

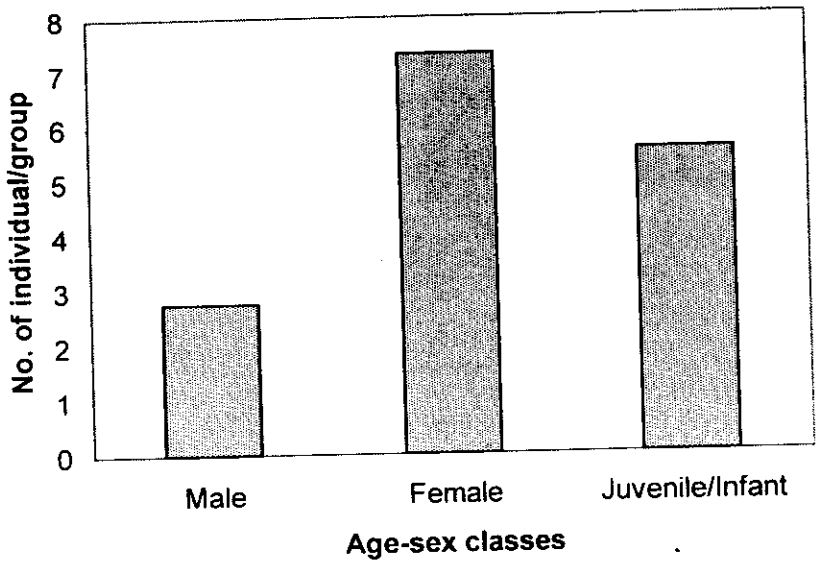


Fig.9. Group composition of spotted deer in the Sundarbans

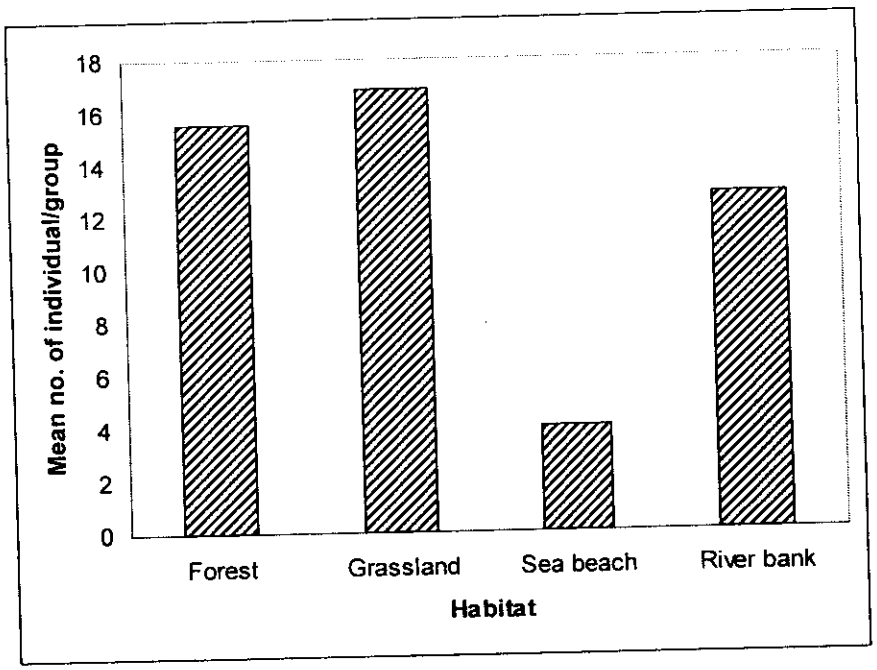


Fig.10. Mean group size of spotted deer in different habitat of Katka-Kachikhali area

4.7 Effect of fresh water availability in the study sites

The presence of fresh water is very much essential for the spotted deer (Lydekker, 1907; Brander, 1923; Graf and Nichols, 1966; and Schaller, 1967). The spotted deer frequently visit water sources daily and sometimes twice a day in the study site. Night observations were on a limited basis yet it was found that spotted deer drink more often at night in Kochikhali. The salinity of the fresh water pond of Katka-Kochikhali was measured with a salinity meter. In the field the tracks of the spotted deer was counted surrounding the bank of the pond considering 1 meter width from the water level. During the study period, the maximum number of tracks (219.75) was found in pond 1 which had the lowest salinity (0.1o/oo) and the minimum number of tracks were found in the pond with the highest salinity of 1.1o/òo. Here the number of track was only 13.75, i.e. the number of track around the pond and the salinity of the water had a negative correlation.

Pellets were also found to be less near the highly saline pond. It was however not directly observed how often the spotted deer visit the fresh water hole. There is no fresh water pond at Jongra, so it was not possible to determine the effect of salinity on the spotted deer. In Notabeki, there is a fresh water pond but access is difficult. There is a tub of water in front of the Notabeki forest office and the spotted deer will come there for water, which is sometimes supplied by the forest staffs. There are two more fresh water ponds behind the forest office in Katka-Kochikhali, and another fresh water pond in the grassland near Jamtala watch tower, which is also used by deer.

Table 22. Effect of salinity in different pond in the study sites

Pond	Latitude/longitude	Salinity	Tracks	Pellets	Temperature
Pond 1	N 21°51.233′ E 89°46.448′	0.1	219.75	4	26.4°c
Pond 2	N 21°51.220′ E 89°46.517′	0.2	152	2	27.9°c
Pond 3	N 21°51.228′ E 89°47.117′	1.1	13.75	0	27.6°c
Pond 4	N 21°51.190′ E 89°47.067′	0.2	104.25	3	25.7°c
Pond 5	N 21°51.118′ E 89°47.133′	0.4	145.5	4	28.3°c
Pond 6	N 21°51.764′ E 89°50.194′	-	138.5	6	-

4.8 Food preference

The spotted deer is a browser as well as a grazer. They prefer green grass and especially the young shoots of *Imperata cylindrica*. Spotted deer were found concentrated in huge numbers in grasslands when the young shoots of *Imperata cylindrica* had sprouted. *Imperata cylindrica* is found only in the grassland at Katka-Kochikhali but absent at Jongra and Notabeki. The spotted deer eat the leaves of Keora, Gewa, Baen, Passur, Dhundhul, Amoor and different species of grasses found in the study sites. A preference was observed in the selection of monocotonous plants over dicotonous ones, yet because sample sizes were still limited, the results are not conclusive at this stage (see Appendix 1 for the results of the laboratory analysis).

Table 23. Species found in grassland of Katka-Kochikhali, which were taken by the spotted deer

Scientific name	Family	Bengali/Local name	Type of plant
Imperata cylindrica	Gramineae	Ulu khor	Grass
Fimbristylis sp.	-	-	Sedge
Cyperus exaltatus	Cyperaceae	Mutha gash	Sedge
Fimbristylis acuminata	Cyperaceae	Bindi	Sedge
Cynodon dactylon	Gramineae	Doob grass	Grass
Bacopa sp.	Solanaceae	Brahmy shak	Forb
Panicum sp.	Gramineae	-	Grass
Phragmites karka	Gramineae	Nol kagra	Grass
Acrostichum aureum	Pteridiaceae	Hodo, tiger fern	Fern
Andropogon sp.	Gramineae	Ada gash	Grass
Coccinia cordifolia	Cucubitaceae	Tela kachu	Climber
Solanum indicum	Solanaceae	Spiny eggplant	Herb
Crotalaria saltiana	Leguminosae	Jhonjoni	Shrub
Ipomoea carica	Solanaceae	Raillata	Herb
Clerodendrum viscosum	Verbenaceae	Bhat	Shrub
Acanthus illicifolius	Accanthaceae	Hargoza	Thorny herb
Crossandra undulifolia	Accanthaceae	Crossandra	Herb
Eriochloa procera	Gramineae	Nolgash	Grass
Saccharum spontaneum	Gramineae	Kash	Grass
Nypa fruticans	Palmae	Golpata	Shrub

Table 24. List of plants taken as food by the spotted deer (On the basis of visual observations)

Vernacular name	Scientific name	Family	Type of plant
Kucha, Kusha	*Cyperus javanicus*	Cyperacae	Grass like herb (sedge)
Nol ghash	*Eriochloa procera*	Gramineae	Grass
-	*Imperata cylindrica*	Gramineae	Grass
-	*Ipomoea pescaprae*	Convulvulaceae	Succulent, herb
Dhanchi	*Myriostachya wightiana*	Gramineae	Grass
Nol khgra	*Phragmites karka*	Gramineae	Grass
Keora	*Sonneratia apetala*	Sonneratiaceae	Tree
Jerman lata	*Thunbergia sp.*	Thunbergiaceae	Climber
-	*Bombax ceiba*	-	Grass
Kumb, Kumba	*Barringtonia racemosa*	Barringtoniaceae	Small tree
Bon ghash	*Blumea sp.*	Compositae	Aromatic herb
Bon notoy	*Mallotus repandus*	Euphorbiaceae	Scan dent shrub
Jir	*Ficus sp.*	Moraceae	Tree with aerial rot
Bon jam	*Eugenia fruticosa*	Myrtaceae	Small tree
-	*Cynodon dactylon*	-	Grass

Table 25. Food items taken by the spotted deer (On the basis of visual observations)

Name of the plants	Leaf	Twig	Flower	Seed	Fruit
Keora	+	+	+	+	+
Grass	+	+	-	-	-
Nol grass	+	+	-	-	-
Durba grass	+	-	-	-	-
Chechra grass	+	-	-	-	-
Jerma lata	+	+	-	-	-
Ghash	+	+	+	-	-
Kumb, Kumba	-	-	+	-	-
Bon ghash	+	-	-	-	-
Bon notoy	-	-	+	-	-
Jir	-	-	-	-	+
Bon jam	-	-	-	-	+
Kaila lata	+	-	-	-	-
Nol khagra	+	-	-	-	-

5. DISCUSSION

The present study has been conducted based on 4 months of field work that started at the end of winter (February) and finished by the beginning of the monsoon (mid June). Though the Sundarbans is a vast area, the study has been done in representative habitats of the three saline zones viz. in Notabeki (the high saline zone), in Katka-Kochikhali, (moderate saline zone) and in Jongra (low saline zone). Most work has been concentrated in Katka-Kochikhali. In Notabeki and Jongra, extensive fieldwork was not possible because of limits in time and funding. Animal observations only followed indirect methods (track/pellet count) in these two sites. The study period only covered a part of two seasons; hence any comparison between seasons was not possible within this very short period. However, many significant findings on the habitat preference by the spotted deer in the Sundarbans came out through this work.

A comparative study of track and pellet counts between sites indicated that Katka-Kachikhali had the highest number of both tracks and pellets. Thus it seems that this site supports the highest densities of spotted deer and has the most favourable ecological conditions. Jongra had the lowest number of tracks and similar pellet counts to Notabeki. The findings therefore seems to indicate that the habitat found in Jongra is less preferred by spotted deer, possibly due to the extensive water logging of this area. Notabeki is in a highly saline zone yet seems to have relatively higher density of spotted deer than Jongra, as there is more preferred habitat available.

It was also found that areas with large pneumatophores are avoided by the spotted deer like as in Sundari forest as these pneumatophores hinder their movement.

The utilization of different habitats by spotted deer thus does not only depend on the vegetation type but is also influenced by various other factors. Deer especially prefer to use grasslands that have Keora trees nearby. Thus the results of the study seem to indicate that the distribution and densities of spotted deer may be influenced by among others, the availability of such preferred food items as grasses and Keora (fruits and young twigs) in a habitat that have a mix of preferred food species, open shady spaces, low salinity and an availability of drinking water.

Though the work was preliminary and did not fall in the major part of the study, laboratory analysis of pellets indicates the preference of monocotyledonous over dicotyledonous plants by spotted deer (see Appendix –1).

A continuous year round study is still essential that covers all habitat types including several other study areas (viz, Kalir Char, Mandarbaria, Dhapak, Nilkomol). Only then comparisons between the habitats and between the seasons will be possible for complete understanding of the habitat utilization by spotted deer in the Sundarbans.

REFERENCES

Curtis, S.J. 1933. Working plan for the Sundarbans Forest Division. Ben Government Press, Calcutta.

De, R. 1999. *The Sundarbans*. Oxford University Press, India. 1-75 pp.

Hendrichs, H. 1975. The status of the tiger, *Panthera tigris* (Linne, 1758) in the Sundarbans mangrove forest (Bay of Bengal). *Sonderdruck aus Saugetierkundliche Mitteilungen*, 23. Jgh., Heft 3, Seite 161-199.

Hussain, Z. and Karim, A. 1994. Introduction. In: *Mangroves of the Sundarbans. Vol.2: Bangladesh*, Z. Hussain and G. Acharya (Eds.). IUCN, Bangkok, Thailand. 1-18 pp.

IUCN Bangladesh. 2000. *Red Book of Threatened Mammals of Bangladesh*. IUCN-The World Conservation Union.

Karim, A. 1994. Physical environment and Vegetation. In: *Mangroves of the Sundarbans*. Vol.2: Bangladesh, Z. Hussain and G. Acharya (Eds.). IUCN, Bangkok, Thailand. 11-18, 43 pp.

Khan, M.A.R. 1986. Wildlife in Bangladesh mangrove ecosystem. *J. Bombay nat. Hist. Soc.* 83:32-40

Neamutulla, M. 2001. Ecology of mammalian prey species of Bengal tiger in the Sundarbans. Unpublished M.Sc. thesis. Jahangirnagar Univ.

Reza, A.H.M.A. 2000. Ecology of the Bengal tiger, *Panthera tigris tigris*, in the Sundarbans, Bangladesh. *M.Sc. thesis* (unpublished). Jahangirnagar University, Savar, Dhaka, Bangladesh.

Schaller, G. 1967. *The deer and the tiger: A study of wildlife in India*. University of Chicago Press, Chicago.

Seidensticker, J 1987 Managing tiger in the Sundarbans: experience an opportunity. In Tigers of the World: the biology, biopolitics, management and conservation of an endangered species (R.L.Tilson and U.S. Seal eds.). Pp 416-426. Noyes Publications, Park Ridge, NJ.

Seidensticker, J., Christie, S. and Jackson, P. 1999. Introducing the tiger. In: *Riding the Tiger: Tiger conservation in human-dominated landscapes*. (Eds. J. Seidensticker, S. Christie and P. Jackson) Cambridge University Press, London. 1-3 pp.

Siddiqi, N. A 1999. Effects of abiotic and biotic factors on the seedling recruitment of Heritiera fomes in the mangroves of the Sundarbans, Bangladesh. J. of Trop. Forest Scienc. 11(4).

Siddiqi, N. A. and Choudhury, J. H. 1987. Man-eating behaviour of Tiger (*Panthera tigris tigris*) of the Sundarbans – twenty eight years record analysis. *Tigerpaper*. 14(3): 26-32.

Zahid, M. 2001. Ecology and behaviour of the spotted deer in the Sundarbans. Unpublished M.Sc. thesis. Jahangirnagar Univ.

Appendix – 1. Preference of Monocotyledonous plants than Diocotyledonous plant specices by the Spotted Deer in the Sundarbans of Bangladesh (from faeces)

A laboratory experiment has been done to quantify the ratio of the presence of the plant epidermis monocotyledonous and dicotyledonous plant in the faeces of the Spotted Deer in the Sundarbans of Bangladesh. A total of 12 gm faeces are experimented from 4 samples of 4 different places, varying in vegetation, such as in Grassland; mixed forest mainly with Goran, Gewa and keora; Keora dominant forest and Goran- Gewa dominant forest. Among total 1574 parts of plant epidermis, 934 are from monocotyledonous which is 60% as well as the rest 640 are dicotyledonous as 40% of the total. Its an overall calculation. Specifically it is found that where Grasslands and forests are present adequately the percentage is much more higher in Monocotyledonous (D-1: Kataka, Monocot= 94.074% & Dicot= 5.926%; D-2: Katka, Monocot= 991.447% & Dicot = 8.553%), another place where grasses present only in river bank in very few scale but plenty of keora trees but the percentage is approximately equal (D-7: behind Katka forest office, Monocot= 48.80% & Dicot = 51.20%), the last one where no grassland at all present, hence grasses mean only very few undergrowth of some monocotyledonous plants, shows higher percentage to the Dicotyledonous (A-1: Notabeki, Monocot= 6.227% & Dicot = 93. 773%).

Introduction

The Spotted Deer , in the wild, live on grasses, leaves and fruits, both fallen and from lower branches and foliages and an unidentified species of small red crab, the remains of which have been found in the rumen (Stanford, 1951) . According to Schaller (1967) there are 16 types of grasses are taken by the Spotted Deer. In case of dicotyledonous, they appeared to feed on plants or plant parts that are more succulent.

The feeding habit is influenced considerably by the availability of young and fresh shoots of grasses. Among grasses *Imperata cylindrica, Cynodon dactylon*, and among trees, *Sonneratia apetala* has the highest percentage of their diet supplemented by nutritious leaves and fruits. The scarcity of preferred food species bounds them to live on some other species as well as coarse grasses, old and dry plant leaves due to foliage. Deer mainly live on grasses but where grasses are not available at all they live on leaves of dicotyledonous plants.

Faecal analysis

Fresh pellets have been collected from each fresh defecation from different habitats and are allowed to dry in direct sunlight and finally preserved.

The dried pellets are then grinded and a 1 gm sample is mixed with water and particles larger than 100 micron are separated and stored in 70% ethanol in a Petri dish and then each droplet is put on a glass slide, spread out evenly and covered with cover slip.

To quantify the composition of the faecal material the area of epidermal fragments is measured at a magnification of x 100 using a grid of small squares in the microscope eyepiece. The abundance of each species is represented as a percentage of the total measured fragmented area.

The total findings of the experiment has been shown in the following table

Table 1. Showing the percentage of occurrence of Monocotyledonous and Dicotyledonous plant epidermis in dung and related information

Code	Place	G.P.S.		Vegetation	Date	Time (Hrs)	Mono		Di	
		N.Longitude	E. Latitude				#	%	#	%
D-1	Katka	21^0 51.171′	89^0 47.066′	Grass land	13.4.02	0946	127	94.074	08	5.926
							115	95.041	06	4.959
							141	92.763	11	7.237
D-2	Katka	21^0 51.125′	89^0 46.894′	Go, Ge, Ke	13.4.02	1002	105	89.744	12	10.256
							112	91.803	10	8.197
							103	92.793	08	7.207
D-7	Katka	21^0 51.349′	89^0 46.247′	Keora	15.4.02	1120	73	51.049	70	48.951
							58	41.727	81	58.273
							74	53.623	64	46.377
A-1	Nota-beki	21^0 56.781′	89^0 07.662′	Go-Ge	06.3.02	1010	08	6.557	114	93.443
							11	7.051	145	92.948
							07	5.072	131	94.927

Table 2. Showing the Average of number and percentage of occurrence of Monocotyledonous and Dicotyledonous plant epidermis in Deer dung.

CODE	Place	Monocotyledonous				Dicotyledonous			
		Number		Percentage		Number		Percentage	
		Total	Average	Total	Average	Total	Average	Total	Average
D-1	Katka	383	127.667	281.897	93.960	25	8.333	18.121	6.040
D-2	Katka	320	106.667	274.34	91.447	30	10	25.660	8.553
D-7	Katka	205	68.333	146.34	48.80	215	71.667	153.601	51.20
A-1	Notabeki	26	8.667	18.681	6.227	390	130	281.319	93.773
		934 60.118%				640 39.89%			

A total of 12 gm samples have been experimented, 3 gm from a particular region taking 1 gm at a time.

In sample no D-1, average percentage of monocot is 93.960 whereas dicot is 6.040 that shows deer have exploited the grassland though preferred tree species are present abundantly. The forest and the grassland are very close to each other but they have to graze in the grassland.

In sample no D-2, average percentage of monocot is 91.447 whereas dicot is 8.553 that shows deer have exploited the grassland more though preferred tree species are present abundantly. The forest and the grassland are very close to each other also here but they have to graze in the grassland. This pellet has been collected from the deep of the mixed forest.

In sample no D-7, average percentage of monocot is 48.80 whereas dicot is 51.12 that shows deer have exploited the grassland and forest equally. This pellets have been collected from inside the forest behind the Katka forest office, hence grassland means the grasses present in the river bank which is few in scale but deer tried to exploit it

though during high tide it goes under water. More experiment could show higher percentage of Monocotyledonous.

In sample no A-1, average percentage of monocot is 6.227 whereas dicot is 93.773 that shows deer have exploited the tree species in the forest because of the absence of grassland. These pellets have been collected from Notabeki. If any scale grassland would available, they would exploit it. They have to depend on dicots as they have no option without it.

The combined percentage of monocot in whole experiment is 60.108 which is higher than the dicot that is 39.892, that shows the deer like grass land than the dicot plant species in forest.

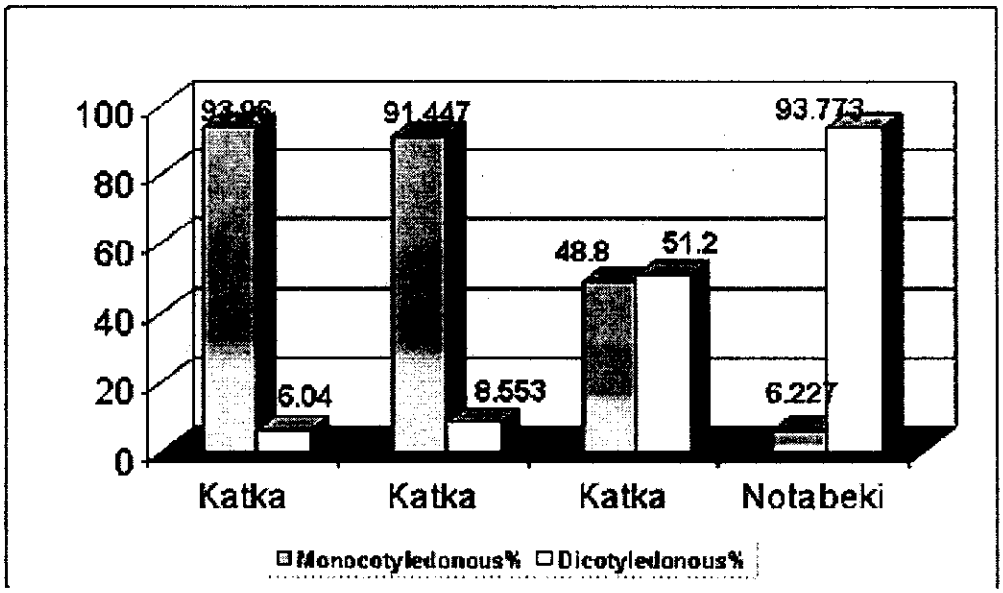
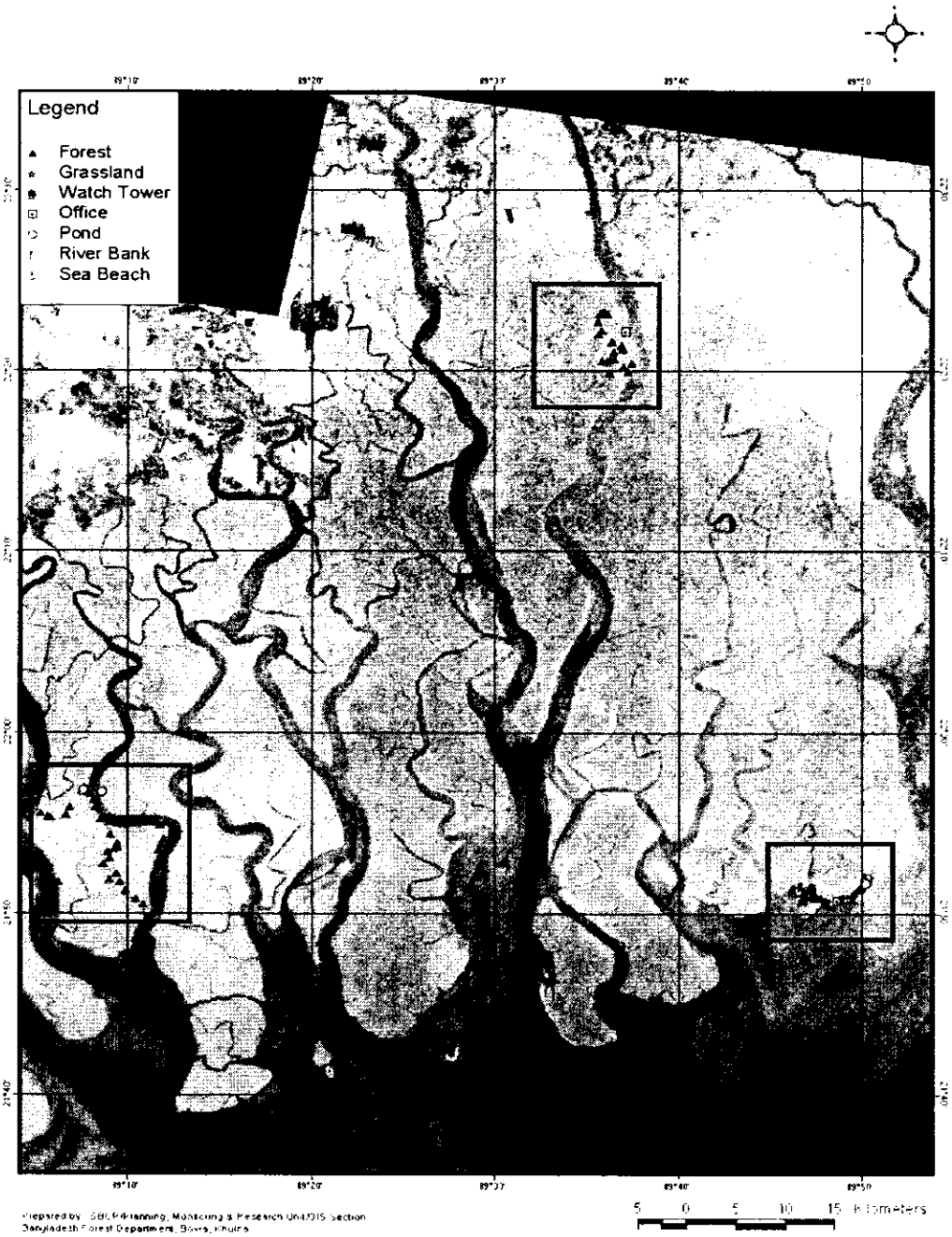


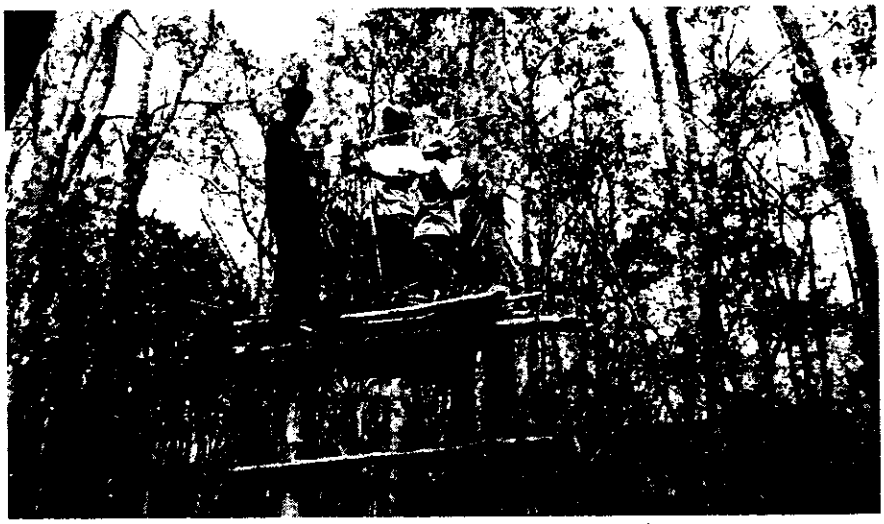
Fig. 1. Percentage of Monocotyledonous and Dicotyledonous plant remains in deer pellets.

Appendix-2. GPS coordination of all plots used for track and pellet count in different study sites.

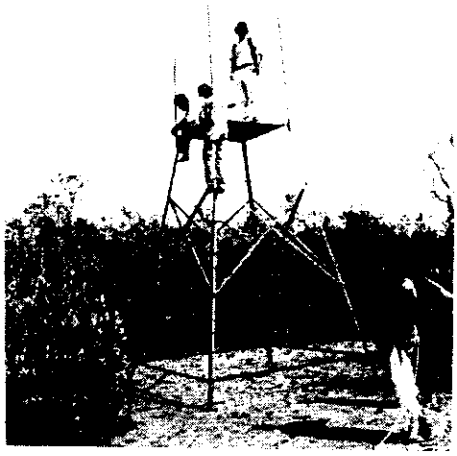


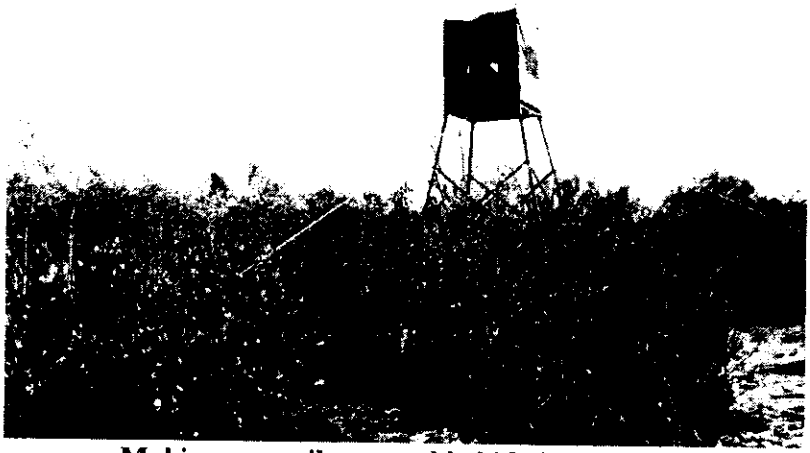
Appendix-3. Photos on different activities and habitat of the study sites.

Study team in the field



Temporary hide for deer observation

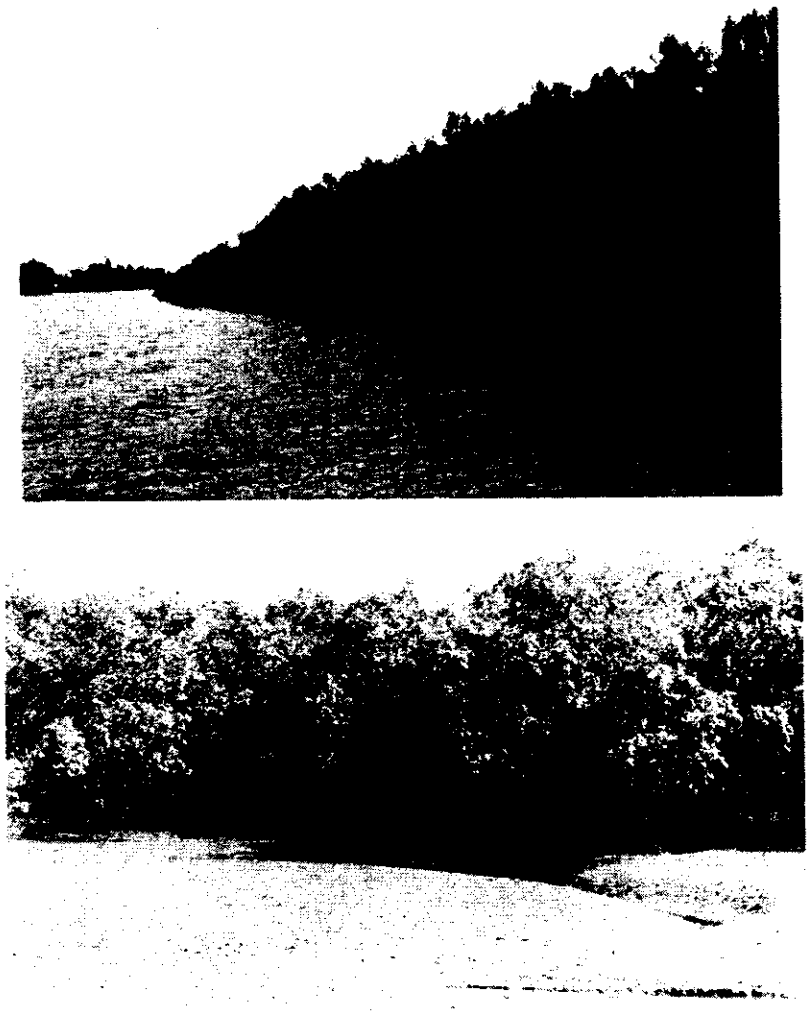




Making an easily moveable hide in Notabaki

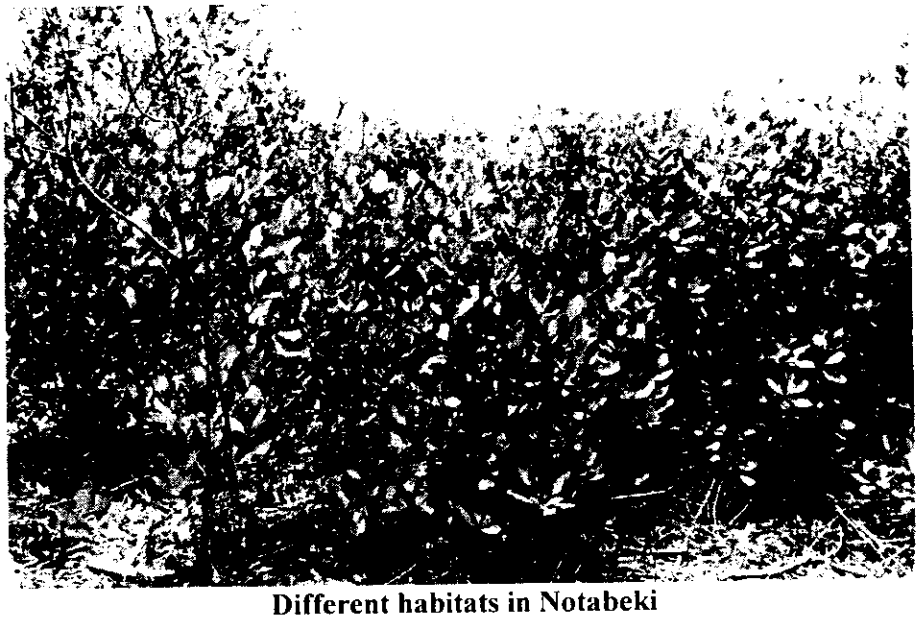
Different deer habitats in Katka-Kochikhali

Different habitats in Katka-Kochikhali



Different habitats in Katka-Kochikhali

Different habitats in Jongra



Different habitats in Notabeki