

**FOOD HABITS OF TIGER (*Panthera tigris tigris*) IN SARISKA TIGER  
RESERVE, RAJASTHAN**

**DISSERTATION SUBMITTED TO  
SAURASHTRA UNIVERSITY, RAJKOT  
IN PARTIAL FULFILLMENT OF  
THE MASTER'S DEGREE IN WILDLIFE SCIENCE**

**BY**

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**UNDER THE SUPERVISION OF**

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## CERTIFICATE

This is to certify that Mr. D. Avinandan of Wildlife Institute of India has carried out an original research work titled 'Food habits of tiger in Sariska Tiger Reserve, Rajasthan' for the partial fulfillment of Master's Degree in Wildlife Science from Saurashtra University, Rajkot. These investigations were carried out under our supervision from November 2002 to June 2003. We also certify that this research work has not been submitted for any degree to any other University.

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## **DEDICATION**

**Dedicated to Paddle and Polly, the two-baby rose ringed parakeets  
(*Psittacula krameri manillensis*) who died under my very nose.**

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## ABSTRACT

Tigers are found in diverse habitat types including dry deciduous, moist deciduous, semi-evergreen, wet evergreen, riverine, swamp and mangrove forests. Tiger is territorial and wide ranging but the effective size of the territory is the function of density and biomass of larger prey species in its habitat. Studies have indicated clear relationship between prey biomass and tiger density across tiger sub species. This makes species vulnerable to changes in prey base and habitat quality. The present study aims at understanding relationship between tiger and its prey in a semi arid tract. The study was conducted in Sariska Tiger Reserve, Rajasthan, over a period of six months, from November 2002 to April 2003. Density estimation of major wild and domestic prey species was done to assess availability to tigers in terms of density and biomass. The line transect method was used for estimating prey density. Twelve line transects were laid in two different strata- plains and hills. Each transect was walked seven times. A total of 87.5 km transect in scrubland and 86.1 km in hills were walked in six months totaling to 173.6 km. Sariska Tiger Reserve was observed to have a very high wild ungulate density of 58.78 animals/km<sup>2</sup>. Chital was the most common ungulate species (27.62/km<sup>2</sup>) followed by Wild pig (17.53/ km<sup>2</sup>), Sambar (8.44 km<sup>2</sup>) and Nilgai (5.19 km<sup>2</sup>). Seventy-seven tiger scats were collected opportunistically from the study area and analyzed for prey remains. Scat analysis revealed that sambar constituted the major prey species in terms of number and biomass. It was the principle and preferred prey ( $P < 0.05$ ) of tigers. Chital was avoided in proportion to the available group and individual density ( $P > 0.05$ ).

From the current study it is evident that tigers were heavily dependent on sambar in greater proportion to their availability and the survival of tigers in Sariska is largely dependent on protecting the habitat of this large cervid. Other medium sized and large sized prey species including domestic livestock contributed significantly to the tiger diet. The ranking on the basis of group density was sambar>cattle-buffalo>nilgai>chital>common langur and wild pig. The order of selection on basis of prey occurrence in scats was sambar>chital>nilgai>cattle-buffalo>common langur >wild pig. A long-term study on tiger ecology in Sariska covering the entire reserve is proposed to get a more detailed understanding of the prey-predator relationship and effective long-term management of tigers in the semi-arid tract.

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# 1. INTRODUCTION

Tigers are found in diverse habitat types including dry deciduous, moist deciduous, semi-evergreen, wet evergreen, riverine, swamp and mangrove forests. They show remarkable tolerance to variation in altitude, temperature and rainfall regimes (Sunquist *et al.*, 1999).

Historically, the tiger was distributed over a wide geographical region that extended from Russia far east, through southern China, south east Asia, the Indian subcontinent, and in to the Indus River Valley in Pakistan (Seidensticker 1997). In the last hundred years three out of the eight subspecies of tigers (Caspian, Javan and Bali) have gone extinct (Seidensticker 1986, 1987, 1997). It is the largest obligate terrestrial carnivore in any of the mammalian assemblages in which it occurs preying on the larger ungulates living in those assemblages (Seidensticker 1997). Tiger is territorial and wide ranging, but the effective size of the territory is the function of density and biomass of larger prey species in its habitat (Karanth 1991, Sunquist 1981). This makes the species vulnerable to changes in the habitat and prey base (Karanth 1991). Degraded habitat and depleted prey base may cause the species to depend more or solely on the domestic livestock available in and around the area giving way to the problem of human-animal conflict. Subsequent degradation may eventually compel the animal to increase its home range further compounding human animal conflicts (Karanth 1991, Gogate *et al.*, 1997, Vanak 1997).

The Indian Tiger (*Panthera tigris tigris*) constitutes almost sixty percent of the present population of tigers in the wild.

The Sariska Tiger Reserve spanning 800 km<sup>2</sup> is one of the important protected areas in the semi-arid tracts of western India. It harbors a population of 10-20 tigers (Johnsingh *et al.*, 1997). It is one of the western most distributions of tigers in India. The future of this population is highly

insecure due to the immense biotic pressure caused by large human and livestock population (Johnsingh *et al.*, 1997). There are two state highways: the Alwar-Thanghazi–Jaipur state highway, and the Sariska-Kalighati-Tehla road, which are over 44 km in length found in the heart of the reserve. The vehicular traffic and the resulting pollution and noise cause enormous disturbance to the wildlife (Johnsingh *et al.*, 1997) Mining, particularly for dolomite is a serious problem in the southern part of the Tiger Reserve, threatening the habitat in the reserve.

The Core I of the Tiger Reserve was notified as 'National Park' in 1982. There are 12 villages located in this area and they are due for relocation since 1984 (Sankar 1994, Johnsingh *et al.*, 1997). This area has 120 km<sup>2</sup> of intact forest, is capable of sustaining a high density of prey species and could support up to 20 tigers in the forthcoming decades (Sankar 1994, Johnsingh *et al.*, 1997). Under these circumstances, importance of basic research on tiger ecology (e.g. Feeding ecology, habitat utilization) continues to be vital for tiger conservation.

## 2. LITERATURE

Our knowledge of tiger ecology primarily rests on the studies done in Indian subcontinent over the past three decades. Different aspects have been studied by different workers in the field e.g. **General Ecology**-Schaller (1967), Johnsingh (1983), **Social organization**-Sunquist (1981): **Land tenure system**-Panwar (1979) Smith *et al.*, (1987), Gogate *et al* (1997), Vanak (1997), Mathai (1999), Chundawat *et al.*, (1999): **Dispersal and communication**-Smith (1984): **Effect on prey species**-Tamang (1983), Karanth (1993): **Prey selection**-Karanth and Sunquist (1995), **Food Habits**-Schaller, (1967), Johnsingh, (1983), Johnsingh *et al.*, (1993), Sankar (1994), Stoen (1994), Sankar and Johnsingh (2002), Biswas and Sankar (2002); and **Tiger-Leopard interaction** - Seidensticker (1976). Besides these, a lot of **natural history** account and some short-term studies are also available on tigers e.g. Corbett (1944), Mc Dougal (1977) Sankhala (1977), Singh (1984), and Thapar, (1986,1989, 1996).

Above-mentioned studies give us an outlook of tiger's ecology from only some of the habitats where it occurs. The distribution of tiger over a varied range of habitats demand studies on the animal's ecology where it is not being looked into.

Feeding Ecology is the integral part of any carnivore study and holds equally true in case of tiger. According to the optimal foraging theory most of the large predators go for the biggest prey within their prey size range (PSR) to maximize their effort (Griffiths 1975). Some studies indicate this pattern in case of tigers (Sunquist 1981, Karanth and Sunquist 1995), but in many cases the pattern is not so obvious. The main condition for that is probably the depleted condition of the larger bodied prey species depends on factors like size and age structure of prey species population, their dispersion in space and time, social organization and anti predator strategy (Sunquist and Sunquist 1989).

To know how tiger is selecting the prey we need to know the feeding ecology of the species from the entire different habitat it occupies. This will give us an idea of the range responses of tigers to the varying prey base assemblages. Here selectivity is defined as killing of prey types in frequencies that were different from those expected, based on their availability in the environment (Chesson 1978).

The proposed study aims to look at this aspect of tiger ecology in Sariska Tiger Reserve (STR), Rajasthan. Besides tiger, the other large carnivore found in Sariska is leopard (*Panthera pardus*). The major prey species for tigers in Sariska are chital (*Axis axis*), sambar (*Cervus unicolor*), nilgai (*Bosephalus tragocamelus*), domestic buffalo (*Bubalis bubalis*) and common langur (*Presbytis entellus*) (Sankar 1994, Sankar and Johnsingh (2002). Sankar and Johnsingh (2002) reported that chital, sambar and common langur contributed to more than 90% of the biomass of tiger diet in Sariska. As in the Core Area I, which is the notified National Park by the park authorities, the people and livestock are not relocated outside till date. There were 8,000 buffaloes reported to be grazing inside the Tiger Reserve during 1994 (Sankar 1994). It would be interesting to know is there any shift in prey base selection by tigers in the same study area after 12 years.

### **3. STUDY AREA**

#### **3.1 LOCATION**

The study area is the Sariska Tiger Reserve (STR), Rajasthan. The park lies between 74°17' E to 76°34'E and 25°5 to 27° 33 N and is situated in the Aravalli Hill Range and lies in the semi arid part of Rajasthan (Rodgers and Panwar 1988). It became a wildlife sanctuary in 1955 and Tiger Reserve in 1982. It is one of the key protected areas as far as the tiger distribution is concerned in western India. The total area of the Tiger Reserve is 800 km<sup>2</sup>, of which 302.2 km<sup>2</sup> is buffer zone and 497.8 km<sup>2</sup> is the core zone. Sariska core zone is distributed in three isolated pockets: the core I (273.8 km<sup>2</sup>), core II (126 km<sup>2</sup>) and core III (97.5 km<sup>2</sup>). The status of the first pocket has been notified as a National Park in 1982. Kiraska and Kankwari are the two large Plateaus in Sariska, and there are two large lakes - Mansarovar and Somasagar. Silisad Lake is situated along the northeastern boundary of the reserve. The altitude of Sariska varies from 540 to 777 m.

#### **3.2 TERRAIN**

Sariska terrain is undulating to hilly in nature and has numerous narrow valleys. The major part of the area is occupied by rocks of the Delhi system and Aravalli system comprising of quartzite, conglomerates, grits, limestone, phyllites, granites and schists (Pascoe 1950). Most of the high ridges comprise of quartzite, conglomerates and grits. The inter linking valleys consist of limestone, phyllites and schists. Soil differs depending on the underlying rocks. They are comparatively rich, fertile and dark coloured soil in plain and river valleys.

#### **3.3 CLIMATE**

The climate of this tract is subtropical, characterized by a distinct summer, monsoon, post monsoon and winter. Summer commences from mid March

and continues till end of June (max temperature recorded was 44° in March, (Sankar 1994)). The monsoon season extends from July to August when the bulk of the rainfall from southwest monsoon occurs. The study area also receives occasional winter and summer rains. In winter the temperature has been observed to drop to 3° C.

### 3.4 VEGETATION

The vegetation of Sariska falls under Northern Tropical Dry Deciduous Forests (subgroups 5 B: 5/E1 and 5/E2) and Northern Tropical Thorn Forest (sub group 6 B)(Champion and Seth 1968.)

*Anogeissus pendula* is the dominant tree species in the undulating area and on the hills. *Boswellia serrata* and *Lannea coromandelica* grow on steep rocky areas. *Acacia catechu*, *Zizyphus mauritiana* and *Butea monosperma* are found in valleys. *Dendrocalamus strictus* is extremely limited in distribution and is found along well drained reaches of the streams and moist and cooler parts.

### 3.5 PREY SPECIES

Besides chital, sambar, nilgai, common langur and wild pig, the other ungulate prey species found in Sariska are the four horned antelope or chowsingha (*Tetracerus quadricornis*). A few Chinkara (*Gazella gazella*) were reported from the buffer zone around Baleta of the tiger reserve during late eighties (Sankar pers.com.). Other wild prey species found in the reserve are common langur, rhesus macaque (*Macaca mulatta*), porcupine (*Hystrix indica*), rufous tailed hare (*Lepus nigricollis ruficaudatus*), Indian peafowl (*Pavo cristatus*) and grey partridge (*Francolinus pondicerianus*) (Sankar 1994). The predominant domestic livestock found inside the reserve are buffaloes, brahminy cattle (*Bos taurus*) and goats (*Capra hircus*).

### **3.6 HUMAN SETTLEMENTS**

There are 17 revenue villages located inside the Sariska Tiger Reserve, of which 13 are located in and around the out-skirts of the Buffer zone and three villages Deori, Dabli and Kiraska are situated in the Core I. Twelve villages are due for relocation since 1984 in the notified National Park of the reserve. Besides this, there are six grazing camps or *Guadas* namely Kankwari, Umri, Haripura, Lilunda, Sukola and Rotkala in Core I. In the revenue villages the occupation of the people is based on agriculture but in the grazing camps it is animal husbandry. A large number of buffaloes and goats, a few cattle and camel are kept in the villages. Thousands of migratory sheep pass through the buffer zone during July to October (Sankar 1994).

#### **4. OBJECTIVES OF THE STUDY**

The following are the objectives of the proposed study:

1. To estimate prey availability (wild and domestic prey) for tigers, in terms of prey density.
2. To analyse the proportion of prey consumed by tigers (by analyzing the scats from the study area) and
3. To estimate prey selectivity by tigers.

#### **5. DURATION AND PERIOD OF STUDY**

This is a study spanning a time period of eight months from November 2002 to June 2003

including six months for fieldwork and two months for data analysis and report writing.

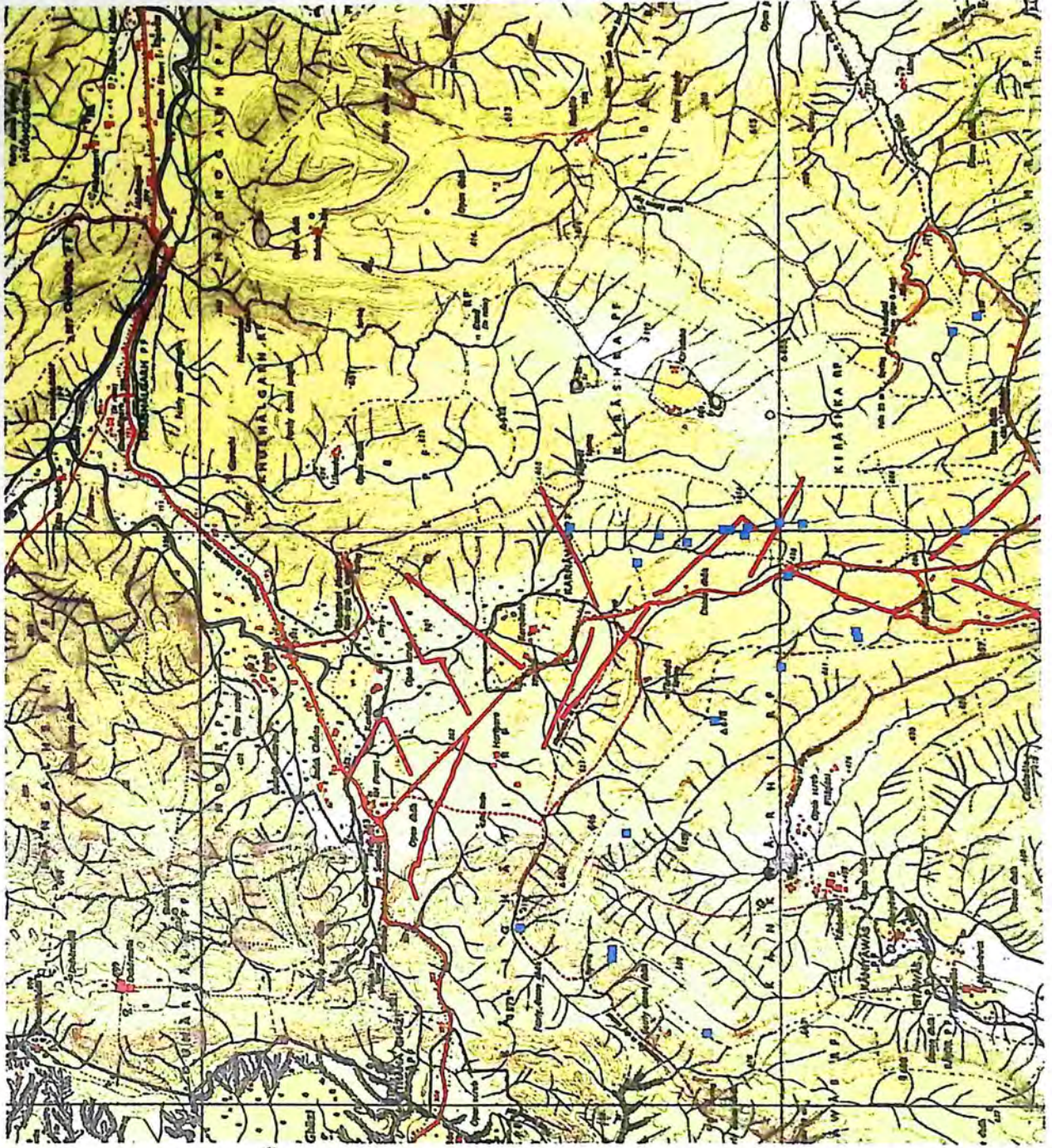
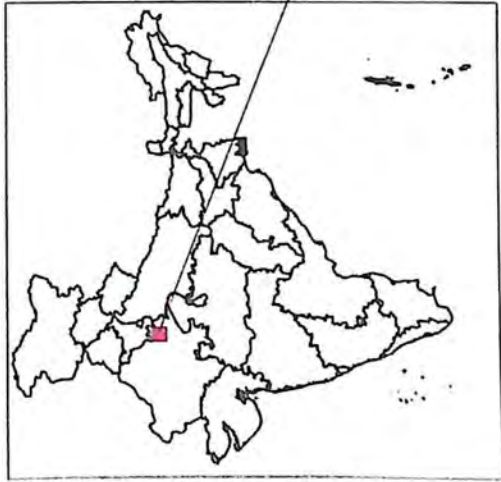
## 6. METHODS

### 6.1 ESTIMATION OF PREY AVAILABILITY

Prey density is widely considered as the indicator of availability of prey to the Tiger (Johnsingh 1983, 1993, Karanth and Sunquist 1995, Mathai 1999). To estimate the density of wild prey species, line transect method was used (Sunquist 1981, Karanth and Sunquist 1995, Chundawat *et al.*, 1999). Line transects were laid in the intensive study area (Core Zone I) (Figure 6.1) which is approximately 45 square kilometers in size. The theory and application of line transect method is dealt in detail by Burnham *et al.*, (1980) and Buckland *et al.*, (1993).

The study area was stratified into two broad categories based on vegetation and terrain. The first strata was scrubland in plains dominated by *Capparis - Zizyphus- Acacia - Balanitis*, and the second strata was *Anogeissus-Boswellia-Acacia* mixed woodland on the hills. A detailed vegetation and terrain profile of line transects laid in the study area is given in table 6.1. Densities of wild and domestic prey species were estimated for both strata and for the whole study area. . Six transects were laid in each habitat with the length of each transect varying from 2 km to 2.4 km (table 6.1). The total length of true replicates in each of the habitats was 12.5 km in scrubland and 12.3 km in the hills. All the transects were walked seven times during the course of the study period. At least one field assistant accompanied me during the walks. The total length of transects walked in each strata was 87.5 km and 86.1 km respectively. The transects were walked early in the morning in the first three hours after sunrise when the animals are said to be most active (Schaller 1967). On all the transects, all species considered as potential prey for tigers were counted. This includes peafowl, Common langur, wild pig, domestic livestock including cattle and buffaloes, nilgai, chital and sambar. For each cluster of prey animals encountered on the transects the following parameters were noted:

Figure 6.1: Map of Study Area (Sariska Tiger Reserve) Showing the Location of Line Transects and Scats



1 0 1 Kilometers



■ Scat Locations  
— Line Transect

**Table 6.1: Line transect profile in the study area (Sariska Tiger Reserve, Rajasthan)**

| <b>Transect no.</b> | <b>Length (km)</b> | <b>Vegetation type</b> | <b>Dominant plant species</b> | <b>Terrain</b> | <b>Disturbance</b> |
|---------------------|--------------------|------------------------|-------------------------------|----------------|--------------------|
| 1                   | 2                  | Scrubland              | <i>Ziziphus</i>               | Flat           | Very High          |
| 2                   | 2.2                | Scrubland              | <i>Capparis</i>               | Flat           | High               |
| 3                   | 2                  | Mixed forest           | <i>Butea - Anogeissus</i>     | Flat and Hilly | Low                |
| 4                   | 2                  | Dense Scrub            | <i>Acacia, Adathoda</i>       | Flat           | Low                |
| 5                   | 2.4                | Mixed forest           | <i>Acacia, Anogeissus</i>     | Hilly          | Low                |
| 6                   | 2                  | Woodland               | <i>Anogeissus</i>             | Hilly          | Nil                |
| 7                   | 2.1                | Mixed forest           | <i>Acacia, Zizyphus</i>       | Flat and Hilly | Low                |
| 8                   | 2                  | Woodland               | <i>Anogeissus, Boswellia</i>  | Hilly          | Nil                |
| 9                   | 2                  | Woodland               | <i>Anogeissus</i>             | Hilly          | Nil                |
| 10                  | 2                  | Woodland               | <i>Boswellia</i>              | Hilly          | Nil                |
| 11                  | 2.1                | Woodland               | <i>Anogeissus, Boswellia</i>  | Hilly          | Nil                |
| 12                  | 2                  | Scrubland              | <i>Capparis, Zizyphus</i>     | Flat           | High               |

1. Time
2. Species
3. Cluster size
4. Radial distance (Using *Yardage Pro 400* Rangefinder)
5. Sex and age (whenever possible) and
6. Sighting angle.

The density of all prey species was calculated using the Distance program *Version 3.5* (Laake *et al.*, 1998). The analysis involved fitting of different models based on detection function to the observed data for estimation of densities. A robust model is the one which can fit with a number of different observed data sets. The best estimate was then taken for the model, which gave the lowest Akaike Information Criteria (AIC) values (Burnham *et al.*, (1980), Buckland *et al.*, 1993).

## **6.2 RECONSTRUCTION OF TIGER DIET**

Feeding ecology of carnivores are usually studied using different methods like observation in the field, stomach content analysis, identifying kills and analysis of scat (Reynolds and Aebischer 1991). Of these methods scat analysis is considered the most suitable method for this study since it is non invasive and cost and time effective (Schaller 1967; Kruuk 1972; Sunquist 1981; Johnsingh 1983, 1993; Karanth and Sunquist 1995). Field conditions does not allow locating all possible kills made by tiger in Sariska, (Sankar 1994), which ideally would have given the best estimate of the animals' diet. This leads to an inherent bias in the kill data by under estimating the utilization of smaller prey, since smaller prey kills will be consumed faster and are less likely to be located than that of larger ones (Sunquist 1981, Johnsingh 1983, Karanth and Sunquist 1995).

## **6.3 COLLECTION OF SCATS:**

Tiger scats were collected wherever encountered in the intensive study area. For each of the tiger scats collected, the following information was recorded:

date, time, location (trail, road, nallah etc.), latitude and longitude (Global Positioning System- Garmin 12XL), fresh or old, substrate, weather condition, and season. The location of scats collected from the study area is shown in figure 6.1. Pugmarks and any associated signs (scrapes, claw marks on trees) if encountered, were also noted down around the site in which the scat was collected. During the entire study period efforts were made to locate the kills of prey species made by the tiger.

Scats were then washed with water, holding over sieve. After the scats were washed in running water, they were dried in direct sunlight. Any remains of bones, quills, teeth or undigested body parts of prey species were separated and the information was recorded for each scat. Washed hair were then sun dried and kept in ziplock bags with naphthalene for further analysis.

#### **6.4 IDENTIFICATION OF THE SCATS**

Tiger scats were distinguished from leopard scats by the size of the scat and associated pugmarks as described by Sunquist (1981), Karanth and Sunquist (1995), and Biswas and Sankar (2002). Tiger scats were found to be less coiled and having larger distance between two successive constrictions within a single piece of scat, when compared to leopard which were mostly coiled and have similar distance between constrictions (Sankar pers. comm.).

#### **6.5 IDENTIFICATION OF PREY REMAINS FROM SCATS**

Hairs from the scats were used for identification of prey species, because it passes undigested through the gut and can be used for species identification (Sunquist 1981, Karanth and Sunquist 1995; Mukherjee *et al.* 1994a, 1994b). At least, 20 hairs were picked up randomly from the scats after washing for the identification of the species. The prey species was identified based on the following parameters as described by Mukherjee *et al.*, (1994b).

1. Hair Width
2. Medullary Structure
3. Medullary width/hair width ratio

Sample slides prepared were compared with reference slides available in the laboratory of Wildlife institute of India, Dehra Dun.

Sample size needed to construct tiger diet was estimated by bootstrapping prey presence data in scats. The variance in data significantly reduced after 60 scats suggesting that the sample size collected is adequate to construct tiger diet (Annexure 2). Quantification of the diet was done by frequency of occurrence method where frequency of occurrence is described as the percentage of scats having hairs of a particular species (Ackerman *et al.*, 1984, Floyd *et al.*, 1978).

#### **6.6 ESTIMATION OF BIOMASS AND NUMBER OF PREY CONSUMED BY TIGER FROM SCAT ANALYSIS, USING A CORRECTION FACTOR**

The biomass and number of individuals of the prey consumed by tiger was estimated using Ackerman's equation (Ackerman *et al.*, 1984) to get a more accurate estimate of prey consumption. This method has already been used in Indian conditions for the estimation of prey consumption by tigers (Karanth and Sunquist 1995, Biswas and Sankar 2002, Sankar and Johnsingh 2002) using following equation:

$$Y = 1.980 + 0.035X$$

X = Average weight of a particular prey type and Y = Kg of prey consumed per field collectible scat (Ackerman *et al.*, 1984).

The assumption for extrapolating of the above equation is that the tigers and cougars have similar utilization and digestibility (Karanth and Sunquist 1995). We also presume that the scats containing various prey items have similar decay rate and their detection is equally probable.

## 6.7 ESTIMATION OF PREY SELECTIVITY

Prey selectivity by tigers was estimated for each species by comparing the proportion of prey species utilized from scats with the expected number of scats in the environment for each of the prey species consumed.

Frequencies of the identifiable prey remains in the scat do not tell us about the actual proportion of prey type eaten. This is more so when the prey types vary in size to a considerable degree. Smaller prey species, having more amount of undigested material (i.e. hair) due to higher body surface to mass ratio. Hence, intake of smaller body sized prey induces relatively more amount of scats production per unit mass of prey consumed leading to an over estimation of smaller prey species in the diet studies of carnivores (Ackerman *et al.*, 1984; Floyd *et al.*, 1978). Correction factor developed by Ackerman *et al.*, (1984), from feeding studies on cougar (*Felis concolor concolor*) was used to estimate the relative proportion of biomass of prey consumed by tigers. Application of this regression equation for tigers involves assuming similar carcass utilization and comparable digestive system of cougars with tigers (Karanth and Sunquist 1995).

Prey selectivity by tigers was estimated for each prey species by comparing their availability and utilization data. The expected proportion of scats in the environment (i.e. availability) was calculated using the following equation (Karanth and Sunquist 1995)

$$f_i = \left\{ \frac{(d_i / dt) * \lambda_i}{\sum \{ (d_i / \sum d_i - d_n) * \lambda_i \}} \right\}, \text{ where}$$

$f_i$  = Expected scat proportion in the environment.

$d_i$  = Density of  $i$  th species

$\sum d_i - d_n$  = sum of density of all species.

$\lambda_i = X/Y$  = The average number of collectible scats produced by tiger from an individual of  $i$  th prey species.

$X$  = Average Body weight of the species

$$Y = 1.980 + 0.035 X.$$

Multinomial likelihood ratio test was used for prey selection (Chesson 1978, Manly 1972, Reynolds and Aebischer 1991, Link and Karanth 1994, Karanth and Sunquist 1995). The exact variability of prey items in scats is not known and in order to account for that sensitivity analysis was done by changing coefficient of variance from 10 to 40% (Link and Karanth 1994). Program Scatman (Link and Karanth 1994) was used to do multinomial test and sensitivity analysis by bootstrapping data 5000 times. To understand the effect of body weight, prey dispersion and group size on prey selection partial correlation was done, controlling for prey availability.

## 7. RESULTS

### 7.1 Availability of prey species

The prey density was estimated for chital, sambar, nilgai, wild pig, common langur, domestic live stock (cattle, buffalo) and peafowl (Table 7.1). The calculated individual and group densities of prey species and encounter rate are given in table 7.1. All the density estimates were done after 1% truncation of the farthest sighting data from the line transect. This was done as suggested by Buckland *et. al.*, (1993) for distance estimation since this helps in better density calculation by omitting the outliers and also helps in best model fit. While estimating density of prey species for the study area, uniform key function with cosine adjustment gave best fit for chital, common langur and nilgai. Where as the model half normal cosine was the best-fitted model for the other prey species (sambar, wild pig, cattle, buffalo and peafowl). The observed effective strip width for different prey species was as follows: Chital: 51.46 m, sambar 40.01 m, nilgai 66.64 m, domestic livestock 93.53 m, common langur 0.23 m, wild pig 67.75 m, and peafowl 47.93 m (Table 7.1). The Probability Detection Function for all the prey species along the line transect analyzed using 'Distance 3.5' software is given in Annexure 1.

#### 7.1.1 Chital

Chital was found to be the most abundant prey species in the study area with individual density of 27.6 animals / km<sup>2</sup> (combined data: plains and hills) (Table 7.1). There was great variation observed in the density of this species in the two strata (Table 7.1). Chital density was very high in the hills and valleys reaching 46.02 individuals/km<sup>2</sup> and low in the plains and scrubland 9.43 individuals/km<sup>2</sup>. The recorded encounter rate for chital along the line transects was 0.57 animals / km walk. Chital mean and median group size was 4 individuals. (Table 7.2). The mean total biomass of chital available per square kilometer was 1242.99 kg (Table 7.3). Chital was spread across 54.16% of the study area (Figure 7.1). Individuals constituted 21.89% of the

observed group size classes in chital. Up to 69.33 % of the groups encountered in the study period consisted of 2-10 individuals (Table 7.2).

### **7.1.2 Sambar**

The observed individual density of sambar in the study area was 8.4 animals/km<sup>2</sup> (Table 7.1). The recorded encounter rate for sambar along the line transects was 0.33 animals / km (Table 7.1). The mean and median group size observed was 3.35 and 2 respectively (Table 7.2). The mean total biomass of sambar available per square kilometer was 1055.20 kg (Table 7.3). Sambar was spread across 66.66 % of the study area. (Figure 7.1). Single individuals constituted 37.97% of the observed group size classes in sambar. Sixty six percent of chital groups encountered in the study period consisted of 2 to 10 individuals. (Table 7.2).

### **7.1.3 Nilgai**

Nilgai individual density in the study area was observed to be 5.2 animals / km<sup>2</sup> (Table 7.1). The recorded encounter rate for nilgai along the line transects was 0.37 animals / km (Table 7.1). The mean and median group size was 2.06 and 1 respectively. (Table 7.2). The mean total biomass of nilgai available per square kilometer was 934.34 kg (Table 7.3). Nilgai was spread across 66.66 % of the study area (Figure 7.1).

### **7.1.4 Common langur**

Common langur was found to be the fourth most abundant prey species in the study area in terms of individual density (14.1 animals / km<sup>2</sup>) and the group density observed was 6.6 groups / km<sup>2</sup> (Table 7.1). The recorded encounter rate for common langur along the line transects was 0.23 animals / km (Table 7.1). The mean and median group size was 13.52 and 12 respectively. (Table 7.2). The mean total biomass of common langur available per square kilometer was 113.06 (Table 7.3). Common langur was spread across 54.16% of the study area (Figure 7.1).

### **7.1.5 Wild pig**

The recorded wild pig individual density in the study area was 17.5 animals / km<sup>2</sup> (Table 7.1). The encounter rate for wild pig was 0.8 animals / km (Table 7.1). The mean and median group size was 2.71 and 2.5 respectively. (Table 7.2). The mean total biomass of wild pig available per square kilometer was 666.06 (Table 7.3). Wild pig was spread across 54.16% of the study area (Figure 7.1).

### **7.1.6 Other prey species**

The individual density of domestic cattle and buffalo (combined data) in the study area was observed to be 6.4 animals / km<sup>2</sup> (Table 7.1). The encounter rate for domestic cattle and buffalo was 0.263 animals / km<sup>2</sup> (Table 7.1). Livestock were spread across 29.166% of the study area (Figure 7.1). The mean total biomass of Livestock available per square kilometer was 1404.32 (Table 7.3). The individual density of peafowl in the study area was observed to be 20.8 individuals / km<sup>2</sup> (Table 7.1) and the group density was 1.9 groups / km<sup>2</sup>. The recorded encounter rate for peafowl along the line transects was 1.04 individuals / km (Table 7.1).

### **7.1.7 Composition of tiger diet**

Altogether 87 prey items were found in 77 tiger scats collected from the study area (Table 7.4). The analysis of 77 tiger scats revealed the presence of seven prey species with a high preponderance of medium to large sized ungulates in the tiger's diet (Table 7.4). Eighty seven percent of tiger scat contained single prey species and 13 % contained two prey species (Figure 7.2). The wild prey species in tiger scats constituted 83.93 percent and where as the domestic livestock (cattle & buffalo) 16.07 % (Fig. 7.3). Of the wild prey species sambar constituted 48.19 percent followed by chital, nilgai, common langur and wild pig with 18.07 %, 14.46 %, 4.81 % and 1.2 % respectively (Figure 7.3).

The estimation of relative biomass contribution of different prey species to tiger diet using the equation developed by Ackerman *et. al.*, (1984) gave a better assessment of prey use than results obtained in terms of frequency of occurrence. The average weight of prey species of tiger required for biomass estimation was taken from Karanth and Sunquist (1995), Khan *et al.*, 1995, and Sankar and Johnsingh (2002).

The wild prey base, in total contributed 74.49 % in terms of relative biomass of prey consumed by tiger (Table 7.4). Of these the wild cervids contributed 73.88% of the total biomass. Where as, the domestic livestock (buffalo and cattle) contributed 25.51 % in terms of relative biomass of prey consumed by tiger (Table 7.4). All the prey species in the study area contributed 559.71 kg to the diet of tiger. Sambar contributed 254.2 kg biomass to the diet of tiger followed by nilgai (99.36 kg), cattle (82.8 kg), buffalo (57.67 kg), chital (53.32 kg), common langur (9.04 kg) and wild pig (3.31 kg) (Table 7.4).

#### **7.1.8 Estimation of prey selectivity**

Sambar was consumed by tiger more than the availability of individuals and groups (Table 7.5 & 7.6, Figure 7.5 & 7.6). Chital, common langur and wild pig were avoided by tiger in terms of both individual and group densities (Table 7.5 & 7.6, Figure 7.5 & 7.6). Nilgai was preferred in proportion to their available individual densities but avoided in proportion to their group densities (Table 7.5 & 7.6, Figure 7.5 & 7.6). Index of selection at individual level prey species by tiger were ranked as sambar > nilgai > cattle & buffalo > nilgai > chital > common langur > wild pig. The ranking on the basis of group density was in the following order: sambar > cattle-buffalo > nilgai > chital > common langur > wild pig. The order of selection on the basis of prey occurrence in scats was sambar > chital > nilgai > cattle-buffalo > langur > wild pig.

Prey selection had shown positive correlation ( $r = 0.57$ ,  $p = 0.19$ ) with prey consumed and body weight. After removal of livestock from analysis, prey

consumption had shown relationship with body weight ( $r=0.77$ ,  $p= 0.22$ ) and prey dispersion ( $r=0.63$ ,  $p= 0.37$ ).

#### **7.1.9 Kill data**

Efforts were made to collect the kills of tiger during the study period. Only eight tiger kills were identified with certainty. Of these, two were chital, two sambar, three cattle and one buffalo. Due to this low sample size no conclusion could be derived regarding the utilization of prey species by tigers. In the intensive study area vultures, wild pigs and jackals disturbed kills and the area around and made it difficult to ascertain the identity of the predator in most of the cases.

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**Table 7.1: Individual and group densities of major tiger prey species estimated using line transect method in Sariska Tiger Reserve, Rajasthan, November 2002 to April 2003.**

| Species            | Model              | Sample Size | Density | SE    | Group Density | S.E   | ESW    | SE    | Encounter rate/km | SE    | AIC      |
|--------------------|--------------------|-------------|---------|-------|---------------|-------|--------|-------|-------------------|-------|----------|
| Chital-Plains      | Uniform Cosine     | 17          | 9.431   | 4.350 | 1.921         | 0.865 | 51.466 | 4.617 | 0.198             | 0.087 | 897.115  |
| Chital-Hills       | Uniform Cosine     | 82          | 46.027  | 8.211 | 9.376         | 1.389 | 51.466 | 4.617 | 0.965             | 0.114 | 897.115  |
| Chital-combined    | Uniform Cosine     | 99          | 27.622  | 7.637 | 5.627         | 0.526 | 51.466 | 4.617 | 0.579             | 0.138 | 897.115  |
| Livestock-Plains   | Half Normal Cosine | 43          | 12.296  | 5.288 | 12.000        | 0.742 | 93.527 | 8.777 | 0.500             | 0.194 | 453.585  |
| Livestock-Hills    | Half Normal Cosine | 2           | 0.579   | 0.593 | 0.126         | 0.593 | 93.527 | 8.777 | 0.235             | 0.024 | 453.585  |
| Livestock-combined | Half Normal Cosine | 45          | 6.472   | 3.356 | 1.407         | 0.780 | 93.527 | 8.777 | 0.263             | 0.118 | 453.585  |
| Langur             | Uniform Cosine     | 40          | 14.132  | 4.868 | 6.636         | 1.180 | 54.915 | 2.813 | 0.234             | 0.068 | 351.435  |
| Nilgai             | Uniform Cosine     | 63          | 5.191   | 1.264 | 1.889         | 0.246 | 66.643 | 3.722 | 0.366             | 0.073 | 584.107  |
| Peafowl            | Half-Normal Cosine | 181         | 20.810  | 6.461 | 1.906         | 0.098 | 47.931 | 3.543 | 1.047             | 0.311 | 1607.700 |
| Wild pig           | Half Normal Cosine | 14          | 17.528  | 0.607 | 2.714         | 0.518 | 67.748 | 0.518 | 0.875             | 0.022 | 130.333  |
| Sambar             | Half Normal Cosine | 57          | 8.442   | 2.531 | 2.289         | 0.269 | 40.011 | 5.085 | 0.333             | 0.088 | 495.469  |

Note : Total transect length walked: 173 km (86.1 km in hills and 87.5 km in scrubland).

Density : Individual density

SE : Standard Error

Group Density : Mean group density of each species encountered during the transect walks

ESW : Effective Strip Width

Encounter rate : Number of animals encountered per kilometer of transect walk.

AIC : Akaike information criterion.

**Table 7.2: Group size classes of different prey species observed in Sariska Tiger Reserve (November 2002-April 2003)**

| Species                   | Sambar      |            | Common langur |            | Nilgai      |            | Chital     |            | Wild pig    |            |
|---------------------------|-------------|------------|---------------|------------|-------------|------------|------------|------------|-------------|------------|
|                           | Frequency   | %Frequency | Frequency     | %Frequency | Frequency   | %Frequency | Frequency  | %Frequency | Frequency   | %Frequency |
| 1                         | 30          | 37.97      | 1             | 4          | 76          | 54.67      | 30         | 21.89      | 6           | 42.85      |
| 2-5                       | 36          | 45.56      | 7             | 28         | 57          | 41         | 66         | 48.17      | 7           | 50         |
| 6-10                      | 9           | 11.39      | 6             | 24         | 5           | 3.59       | 29         | 21.16      | 1           | 7.14       |
| 11-20                     | 4           | 5.06       | 6             | 24         | 1           | 0.71       | 9          | 6.56       | 0           | 0          |
| 21-30                     | 0           | 0          | 3             | 12         | 0           | 0          | 3          | 2.18       | 0           | 0          |
| 30+                       | 0           | 0          | 2             | 8          | 0           | 0          | 0          | 0          | 0           | 0          |
| <b>Total observations</b> | <b>79</b>   |            | <b>25</b>     |            | <b>139</b>  |            | <b>137</b> |            | <b>14</b>   |            |
| <b>Mean Group Size</b>    | <b>3.35</b> |            | <b>13.52</b>  |            | <b>2.05</b> |            | <b>4</b>   |            | <b>2.71</b> |            |
| <b>Median Group Size</b>  | <b>2</b>    |            | <b>12</b>     |            | <b>1</b>    |            | <b>4</b>   |            | <b>2.5</b>  |            |

**Table 7.3: The estimated biomass of prey species in Sariska Tiger Reserve (November 2002 to April 2003).**

| Species       | Density/sq.km | Confidence Interval |       | Avg. Body weight (kg) | Mean Biomass per sq.km (kg) | Confidence interval |         |
|---------------|---------------|---------------------|-------|-----------------------|-----------------------------|---------------------|---------|
|               |               | Lower               | Upper |                       |                             | Lower               | Upper   |
| Chital        | 27.62         | 24.29               | 30.95 | 45.00                 | 1242.99                     | 1093.10             | 1392.88 |
| Livestock     | 6.47          | 6.47                | 6.47  | 217.00                | 1404.32                     | 1404.25             | 1404.38 |
| Common Langur | 14.13         | 7.08                | 21.18 | 8.00                  | 113.06                      | 56.71               | 169.40  |
| Nilgai        | 5.19          | 2.02                | 8.35  | 180.00                | 934.34                      | 364.93              | 1503.76 |
| Peafowl       | 20.81         | 10.00               | 31.62 | 4.20                  | 87.40                       | 42.02               | 132.79  |
| Wildpig       | 17.52         | 16.74               | 18.32 | 38.00                 | 666.06                      | 636.14              | 695.98  |
| Sambar        | 8.44          | 3.88                | 13.00 | 125.00                | 1055.20                     | 485.51              | 1624.89 |
| Total (Kg)    |               |                     |       |                       | 5503.37                     | 4082.67             | 6924.08 |

**Table 7.4 Frequency of occurrence of food items in 77 tiger scats and contribution of different prey species in terms of biomass to the tiger diet in Sariska Tiger Reserve (November 2002 to April 2003).**

| Prey species     | Average Body weight (X) | Prey species remains (F= 87) | Percent occurrence of prey species (n =77) | Relative occurrence (R) in% | Number of collectible scats produced per kill (Y) | Prey biomass consumed (B) = F*Y | Percentage relative biomass of prey contribution (P = F*R In %) |
|------------------|-------------------------|------------------------------|--|-----------------------------|---|---------------------------------|---|
| Chital           | 45                      | 15                           | 19.48                                      | 17.24                       | 3.555   | 53.325                          | 9.52  |
| Sambar           | 125                     | 40                           | 51.95                                      | 45.97                       | 6.355   | 254.2                           | 45.41   |
| Nilgai           | 180                     | 12                           | 15.58                                      | 13.79                       | 8.28  | 99.36                           | 17.75   |
| Wild pig         | 38                      | 1                            | 1.3  | 1.14                        | 3.31  | 3.31                            | 1.59  |
| Domestic buffalo | 273                     | 5                            | 6.49                                       | 5.74                        | 11.535  | 57.675                          | 10.03   |
| Domestic cattle  | 180                     | 10                           | 12.99                                      | 11.495                      | 8.28  | 82.8                            | 14.79   |
| Common langur    | 8                       | 4                            | 5.19                                       | 4.59                        | 2.26  | 9.04                            | 1.61  |
|                  |                         |                              |  |                             |   | 559.71                          |   |

X= Average body weight of an individual prey type in kg

Y (kg of prey consumed per field collectible scat)=1.980+0.035 X (Ackerman et al 1984)

Total Prey Biomass consumed = 559.71 kgs

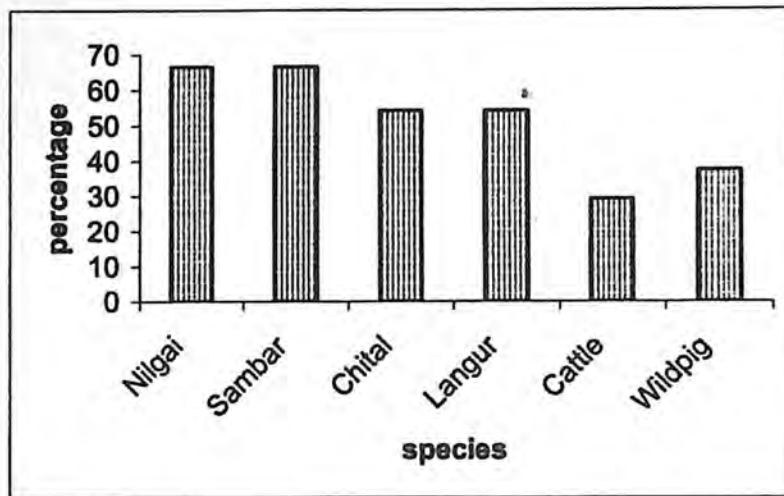
**Table 7.5 : Preference of prey species by tiger in Sariska Tiger Reserve based on availability of individuals and utilization based on scat data (November 2002 to April 2003).**

| Species          | Chi-square value | Un-adjusted P value | Adjusted P-value 10% CV | Adjusted P value 40% CV | S.E    | Ivlev's index-individuals |
|------------------|------------------|---------------------|-------------------------|-------------------------|--------|---------------------------|
| Chital           | 5.9233           | 0.015               | 0.0262                  | 0.0327                  | 0.0006 | -0.266702879              |
| Sambar           | 73.5946          | 0.001               | 0.001                   | 0.001                   | 0      | 0.544163064               |
| Cattle & Buffalo | 2.648            | 0.104               | 0.1721                  | 0.1783                  | 0.004  | -0.196658098              |
| Common Langur    | 0.5591           | 0.455               | 0.4657                  | 0.4698                  | 0.0024 | -0.25093633               |
| Nilgai           | 1.3012           | 0.254               | 0.2753                  | 0.2752                  | 0.0017 | 0.164725458               |
| Wildpig          | 13.2509          | 0                   | 0.0011                  | 0.0013                  | 0      | -0.823530487              |

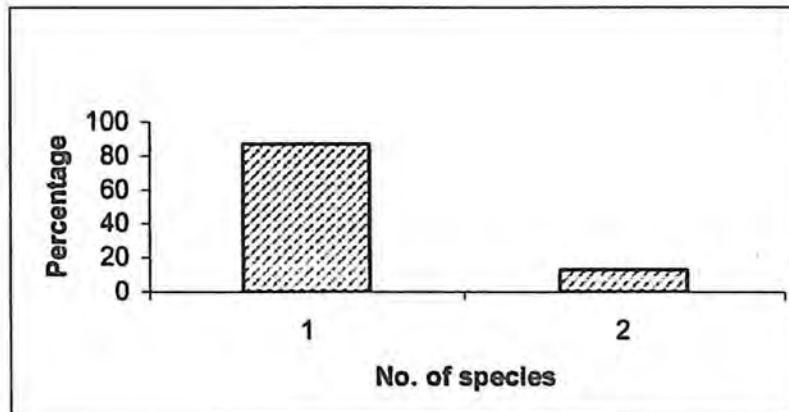
**Table 7.6 : Preference of prey species by tiger in Sariska Tiger Reserve based on availability of groups and utilization based on scat data (November 2002 to April 2003)**

| Species          | Chi square value | Unadjusted P-value | Adjusted P-value 10% CV | Adjusted P value 40% CV | S.E    | Ivlev's index-group |
|------------------|------------------|--------------------|-------------------------|-------------------------|--------|---------------------|
| Chital           | 3.1595           | 0.075              | 0.0955                  | 0.1161                  | 0.0015 | -0.203069658        |
| Sambar           | 43.299           | 0.0001             | 0.0001                  | 0.0001                  | 0      | 0.434857471         |
| Cattle & Buffalo | 0.4563           | 0.499              | 0.571                   | 0.5856                  | 0.0063 | 0.088376143         |
| Common Langur    | 4.6903           | 0.03               | 0.0341                  | 0.0389                  | 0.0003 | -0.587628866        |
| Nilgai           | 0.7898           | 0.374              | 0.4048                  | 0.4183                  | 0.0029 | -0.123539232        |
| Wild pig         | 9.5899           | 0.002              | 0.0025                  | 0.0038                  | 0      | -0.821746881        |

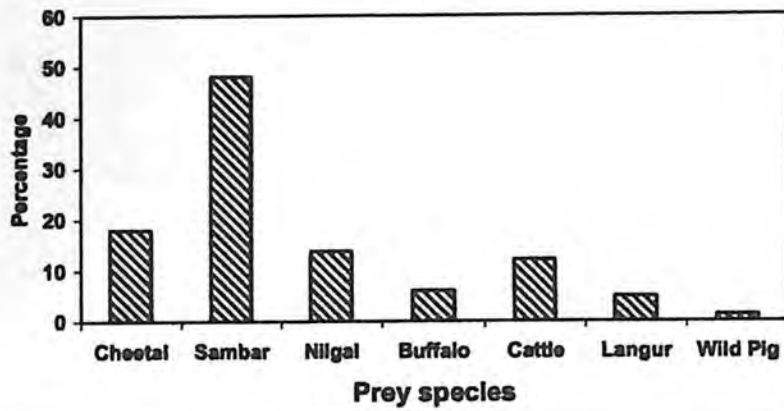
**Figure 7.1: Percentage spread of prey species across the intensive study area (Sariska Tiger Reserve).**



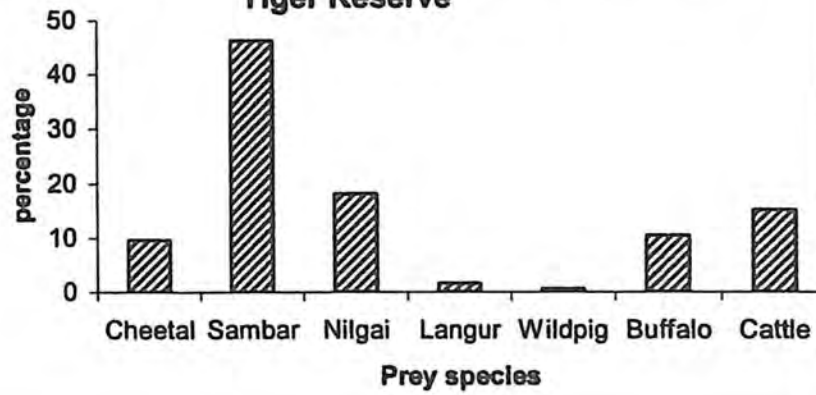
**Figure 7.2: Percentage of prey remains in tiger (n=77) scats collected in Sariska (November 2002 to April 2003).**

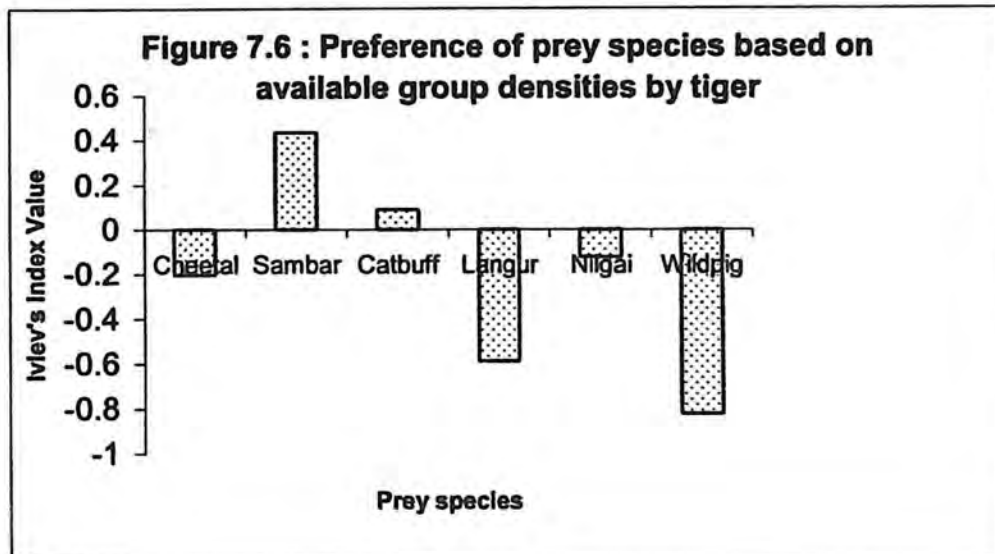
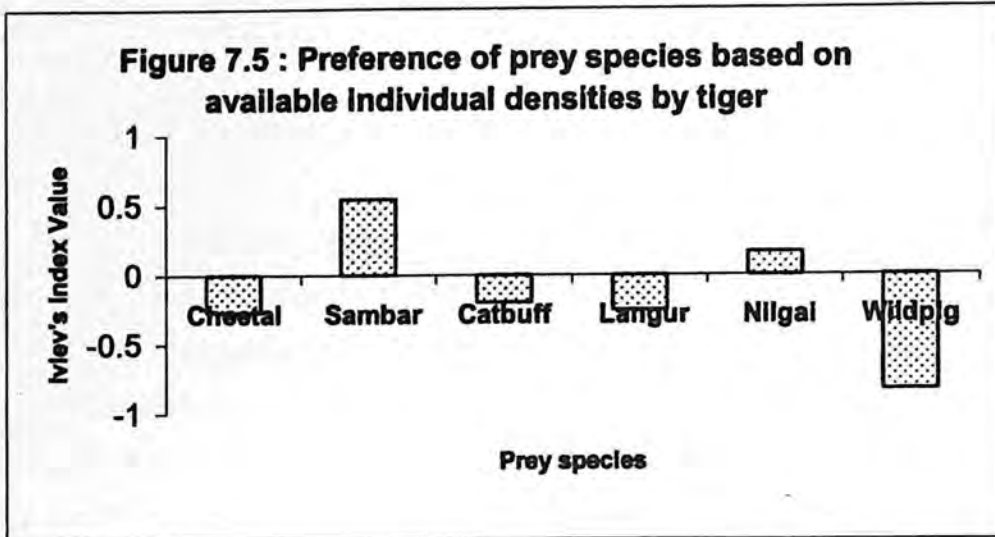


**Figure 7.3 : Percentage occurrence of different prey items in 77 tiger scats.**



**Figure 7.4 : Contribution of different prey species in terms of biomass to the tiger diet in Sariska Tiger Reserve**





## 8. DISCUSSION

### 8.1 Availability of prey species

Chital was the most abundant wild ungulate species in Sariska Tiger Reserve. However the crude density estimates for chital in Sariska Tiger Reserve did not compare favorably with other protected areas in the Subcontinent like Pench (Biswas and Sankar 2002), Kanha, Nagerhole (Karanth and Nichols 1998), Gir (Khan *et al.*, 1996) and Bandipur (Johnsingh 1983). However the crude density of chital in the hills and valleys was observed to be 46.02 animals/km<sup>2</sup> and is comparable to the densities, which occur across other regions in the country. Chital was also the least widespread of the three large wild ungulates found in the study area with a dispersion percentage of 54.17 (Figure 7.1). On the other hand the crude density of chital in the plains was observed to be only 9.43 animals/ km<sup>2</sup>. This could be explained by the heavy disturbance encountered in the plains due to grazing/browsing by domestic livestock (cattle, buffalo and goats) around Haripura village. Chital were largely encountered in the valleys interspersed between the hills and in areas in the plains, which had a high vegetation cover with least disturbance.

The Sambar density in the study area was observed to be 8.44 animals/ km<sup>2</sup> which is higher than the density figures obtained for Kanha, Nagerhole (Karanth and Nichols 1998), Mudumalai (Varman and Sukumar 1995), Chitawan (Seidensticker 1976). Sambar densities in Sariska can be compared with protected areas like Pench (Biswas and Sankar 2002) and Bandipur (Johnsingh 1983). Sambar is predominantly a browser and has evolved in forest environment (Eisenberg and Lockhart 1972). Its' abundance in any particular area probably is limited by the dispersion of the browse species in the forest, the phenophase of browse species and water (Sankar, 1994, Biswas 1999). Of the two cervids, sambar was the most widely and uniformly distributed in the study area. This may be attributed to the fact that a large portion of the terrain is hilly in the study area they were relatively undisturbed.

The nilgai density in the study area was observed to be 5.19 animals/km<sup>2</sup> which is comparable to Royal Bardia National Park (RBNP) (Dinerstein 1980). It is higher than the nilgai densities recorded in Pench (Biswas and Sankar 2002) and Gir (Khan *et al.*, 1996). Nilgai was observed to be widely distributed across the entire study area. However their occurrence was recorded more in the plains than in the hills. This could be attributed to their higher tolerance of anthropogenic pressure than the cervids. The nilgai's wide dispersal in Sariska Tiger Reserve was attributed to its tolerance of disturbance (Sankar and Johnsingh 2002).

The common langur density in the study area was observed to be 14.13 animals/km<sup>2</sup>. It is very low compared to the density observed in Pench, which was 77.16 animals/ km<sup>2</sup> (Biswas and Sankar 2002).

The observed density for wild pigs (17.53 animals/km<sup>2</sup>) was higher than all recorded densities in previous studies - Pench; 2.59 animals/km<sup>2</sup> (Biswas and Sankar 2002), Kanha; 0.8 animals/km<sup>2</sup> Nagerhole; 3.3 animals/km<sup>2</sup> (Karanth and Sunquist 1995), Bandipur; 2.5 animals/km<sup>2</sup> (Johnsingh 1983), Royal Bardia National Park; 4.2 animals/km<sup>2</sup> (Dinerstein 1980) and Chitawan; 5.8 animals/km<sup>2</sup> (Seidensticker 1976) (Table 8.1). Though chowsingha was not encountered during transect walks, their pellet groups were recorded along the transects. This showed the presence of chowsingha in the study area. Sankar (1994) reported low occurrence of chowsingha in Sariska.

The domestic cattle and domestic buffalo were distributed largely in the plains. The buffaloes and goats were accompanied by villagers in the forest and whereas the cattle were left unattended. They largely occurred near human habitation. The grazing and movement of livestock was pre-determined by the villagers.

## **8.2 Tiger distribution and abundance**

It was observed that the tigers were largely distributed in the hilly regions within the study area (Fig 6.1). This is the only area in the entire Tiger Reserve where anthropogenic disturbance is minimal. This was also the region where maximum cervid population was reported by the present and previous studies (Sankar 1994). On the basis of equation (tiger density/100 km<sup>2</sup> = prey biomass/km<sup>2</sup>-256.3/476.5) given by Miquelle *et al.*, (1999) the estimated tiger density in Sariska was between 5 to 11 tigers per 100 km<sup>2</sup> (on the basis of wild ungulate biomass). The tiger density supported per 10,000 kg of prey biomass is far lower when compared to other large felids (Table 8.5).

## **8.3. Prey Selection by tigers**

Sambar was observed to be the principle prey species for tigers as inferred from the percentage occurrence of prey remains in scats (Figures 7.5 & 7.6). Sambar also contributed to the highest biomass of prey consumed by the tiger. It was preferred in proportion to their available group and individual densities. This preference could be attributed to the larger body weight and wide distribution of sambar across the study area thereby the higher frequency of encounter. The tiger distribution range also coincided with the sambar habitat in the reserve. Nilgai were preferred in proportion to their available individual density and were second in terms of biomass contribution to the tiger diet.

Of the prey remains encountered in scats, sambar constituted the maximum amounting to 45.97 % of the total. This is higher compared to the frequency observed in Pench, 13.78%, (Biswas and Sankar 2002), Kanha – 10.4% (Schaller 1967) and Nagerhole – 34.9% (Karanth and Sunquist (1995) (Table 8.2). Chital constituted 17.24% of the total prey remains in tiger scat in Sariska which is less than that was observed from previous studies - Pench, 53.01%, (Biswas and Sankar 2002), Kanha – 52.2% (Schaller 1967), Nagerhole – 31.2% (Karanth and Sunquist (1995) and Bandipur – 39%

(Johnsingh 1983) (Table 8.2). Cattle and buffalo constituted 11.49% and 5.7 % respectively of the remains encountered in the tiger scats. This is higher than the percentage observed for all other areas mentioned above. Sankar and Johnsingh (2002) reported the occurrence of remains of rodents, insectivore, chowsingha, peafowl (*Pavo cristatus*) and Grey Francolin (*Francolinus pondicerianus*) in tiger scats in Sariska. However, during the present study these species remains were not observed in tiger scats. Remains of domestic cattle that was recorded in the tiger scats during the present study was not reported earlier by Sankar and Johnsingh (2002). The biomass of ungulate species compiled from different protected areas in the subcontinent is given in table 8.4. The total biomass of ungulate densities in the study area (Sariska) is observed to be the third highest after Nagerhole and PENCH (Table 8.3).

Predation is an ecological factor, which pervades all levels of ecology, and understanding of it, increases considerably to our knowledge of habits and structure of animals (Curio 1976). Predation includes searching locating, pursuing, and overcoming the prey by the predator (Dunstone and Gorman 1993). Cats are specialized predators and enjoy much in common in terms of their morphology, physiology and their behaviour. (Sunquist and Sunquist 1989). Different factors like abundance of the prey species, temporal and spatial distribution, size, defenses, and anti-predator tactics in different ways constitute the ecological constraints on the predator (Sunquist and Sunquist 1989). In addition, the distribution and abundance of hunting cover, climatic conditions, and the presence and abundance of congeners and other potential predators can also act as limiting factors.

For tigers in the Indian subcontinent, chital and sambar constituted the main prey base wherever they occur in considerable numbers (Schaller 1967, Tamang 1979, Sunquist 1981, Johnsingh 1983, 1993, Johnsingh *et al.*, 1993, Sankar *et al.*, 1993, Stoen 1994, Karanth and Sunquist 1995). Apart from these two species, other species like wild pig common langur, gaur and nilgai are the other common prey species preyed upon by tiger in the subcontinent (Biswas and Sankar 2002, Sankar and Johnsingh 2002). Carbone and

Gittleman (2002) suggested that 10,000 kg of prey support about 96 kg of a given species of carnivore irrespective of body mass, (Table 8.5), and that the ratio of carnivore number to prey productivity scales to carnivore mass near  $-0.75$ , and that the scaling rule can predict population density across more than three order of the magnitude. The prey biomass and level of disturbance are the most critical factor for persistence of tiger population.

### 8.3 Conservation of tigers in Sariska

Mammalian carnivores are characterized by classic relationship with their prey. It seems that carnivores are closely tied not only to prey size but also to prey biomass (Carbone and Gittleman 2002, Karanth and Nichols 1998). Prey density is critical to maintenance of large carnivore population. Looking at current socio-political scenario it is important to maintain core-breeding areas for tigers at landscape level. In any given National Park it is important to maintain mini-cores as a source area for tiger and its prey. In Sariska Tiger Reserve, the Sariska - Kalighati - Pandupole valley (ca. 80 km<sup>2</sup>) is the only area, which can be considered as mini-core. As the rest of the park area is disturbed due to anthropogenic pressure they have very low wild ungulate density and hence it can support only a few tigers (Johnsingh *et al.*, 1997).

Sariska Tiger Reserve is one of the western most distribution of tigers in India. Wickramanayake *et al.*, (1999) classified the Sariska Tiger Reserve as Tiger Conservation Unit -3 (TCU 3) among the dry deciduous habitat types. Of the 45 km<sup>2</sup> study area, the evidences of tiger (tracks, signs, scats) were recorded only from the hilly tracks, which is relatively undisturbed (Figure 6.1). This forms a very small area (ca. 25 km<sup>2</sup>) of the Core Zone 1 and corresponds to the area where there is a high wild cervid density (Sankar, 2004, Sankar and Johnsingh 2002). The reported total tiger population in the entire Tiger Reserve is 26 (Anon. 2002), which comes to 3 animals per hundred square kilometers. As compared to the density of tigers with other protected areas in India (Karanth and Nichols 1998) (Table 8.4) the tiger density in Sariska is very low. On the basis of interview with local forest staff the tiger population in the study area was reported to be 5 to 7 individuals (this was based on

individual pugmark identification and actual sighting records of tiger). The future of this population is highly insecure due to the immense biotic pressure caused by large human and livestock population. There are two state highways: the Alwar-Thanghazi–Jaipur state highway, and the Sariska-Kalighati-Tehla road, which are over 44 km in length found in the heart of the reserve. The vehicular traffic and the resulting pollution and noise cause enormous disturbance to the wildlife (Johnsingh *et al* 1997) Mining, particularly for dolomite is a serious problem in the southern part of the Tiger Reserve, threatening the habitat in the reserve.

The Core I of the Tiger Reserve was notified as 'National Park' in 1982. There are 12 villages located in this area and they are due for relocation since 1984 (Sankar 1994, Johnsingh *et al* 1997). This area has 120 km<sup>2</sup> of intact forest, is capable of sustaining a high density of prey species and could support up to 20 tigers in the forthcoming decades (Sankar 1994, Johnsingh *et al.*, 1997). Under these circumstances, importance of basic research on tiger ecology (e.g. Feeding ecology, habitat utilization) continues to be vital for tiger conservation. A long-term study on tiger ecology in Sariska covering the entire reserve is proposed to get a more detailed understanding of the prey-predator relationship and effective long-term management of tigers.

**Table 8.1 : Densities of ungulate species from different areas in south Asia**

| Species      | PNP   | PNCH | KNH  | GIR  | NGH  | BDP   | MML   | RBNP      | CTW  | STR    | KZR  |
|--------------|-------|------|------|------|------|-------|-------|-----------|------|--------|------|
| Chital       | 80.75 | 51.3 | 49.7 | 57.3 | 38.1 | 43-45 | 25.03 | 29.7-33.9 | 17.3 | 27.622 | NP   |
| Sambar       | 6.09  | 9.6  | 1.5  | 3.5  | 4.2  | 8-9   | 6.61  | -         | 2.9  | 8.442  | ...  |
| Wild Pig     | 2.59  | 0.8  | 2.5  | -    | 3.3  | 2.5   | -     | 4.2       | 5.8  | 17.528 | 2.6  |
| Gaur         | 0.34  | 0.7  | -    | NP   | 4.5  | 0.5   | 14.38 | -         | -    | --     | .... |
| Nilgai       | 0.43  | 0.7  | NP   | 0.58 | NP   | NP    | NP    | 5.0       | -    | 5.191  | NP   |
| Chowsingha   | 0.29  | 0.7  | -    | 0.42 | -    | NP    | NP    | NP        | NP   | --     | .... |
| Wild Buffalo | NP    | NP   | NP   | NP   | NP   | NP    | NP    | NP        | NP   | --     | 2.7  |
| Muntjac      | -     | -    | 0.6  | -    | 6.0  | 1     | -     | 1.7       | 6.7  | --     | .... |
| Hog Deer     | -     | NP   | NP   | -    | NP   | -     | -     | -         | -    | --     | 38.6 |
| Barasingha   | -     | -    | 3.0  | -    | NP   | -     | -     | -         | -    | --     | 14.2 |

PNP (Pench National Park)-Biswas & Sankar 2002; PNCH (Pench Tiger Rserve), KNH (Kanha) &, NGH (Nagarhole)- Karanth & Nichols(1998); BDP (Bandipur)- Johnsingh(1983); MML (Mudumalai)-Varman & Sukumar(1995); RBNP (Bardia)- Dinerstein(1980); CTW (Chitwan)- Seidensticker(1976), STR (Sariska) Present study 2002: NP-not present;- very low density or information not available.

**Table 8.2: Frequency of occurrence of major prey species in tiger (*Panthera tigris tigris*) scats from different areas of the Indian subcontinent**

| Species       | Pench | Kanha | Bandipur         | Nagarhole | Chitwan1 | Chitwan2          | Bardia | Sariska |
|---------------|-------|-------|------------------|-----------|----------|-------------------|--------|---------|
| Chital        | 53.01 | 52.2  | 39               | 31.2      | 33.3     | 61.8 <sup>a</sup> | 77.7   | 17.24   |
| Sambar        | 13.78 | 10.4  | 30.5             | 34.9      | 29.3     | 20.0              | --     | 45.97   |
| Muntjac       | 5.34  | -     | --               | 6.1       | 4.1      | --                | --     | --      |
| Barasingha    | NP    | 8.6   | NP               | NP        | NP       | NP                | 1.4    | --      |
| Hog deer      | NP    | NP    | NP               | NP        | 15.4     | -                 | 7.7    | --      |
| Wild Pig      | 8.88  | 0.8   | 5.5              | 9.4       | 10.6     | 3.6               | 8.8    | 1.1     |
| Gaur          | -     | 8.3   | 5.5              | 17.4      | NP       | --                | NP     | --      |
| Nilgai        | -     | -     | NP               | NP        | -        | --                | 1.9    | 1.37    |
| Chowsingha    | 2.67  | -     | --               | -         | NP       | NP                | NP     | --      |
| Common Langur | 3.65  | 6.2   | --               | 3.9       | 5.7      | 3.6               | 2.3    | 4.59    |
| Cow           | 4.34  | 5.9   | 5.5 <sup>c</sup> | --        | -        | 1.8 <sup>c</sup>  | -      | 11.49   |
| Buffalo       | 2.00  | 1.7   | --               | --        | -        | --                | -      | 5.7     |
| Others        | 6.33  | 6.1   | 14               | 7.1       | 1.6      | 9.0               | 5.2    | 0       |

<sup>a</sup> Includes percent occurrence of chital, hog deer and muntjac

<sup>b</sup> Both domestic and wild pigs

<sup>c</sup> Domestic livestock as a whole

Pench - Biswas & Sankar (2002); Kanha - Schaller(1967); Bandipur -Johnsingh(1983); Nagarhole - Karanth & Sunquist (1995); Chitwan1 - McDougal (1977); Chitwan2 - Sunquist(1981); Bardia - Stoen & Wegge(1996).

**Table 8.3 : Biomass of ungulate species from different tropical areas in South Asia**

| Locality                                  | Forest type                                    | Biomass density kg km <sup>-2</sup> |
|---|--|-------------------------------------|
| Sariska (Present Study)(2002)             | Tropical dry deciduous & Tropical thorn forest | 4082.66-6924.07                     |
| Pench                                     | Tropical dry deciduous forest                  | 6013.25                             |
| Kanha (Schaller, 1967)                    | Tropical moist deciduous forest                | 3902.3 – 4805.7                     |
| Gir(Khan <i>et al.</i> , 1996)            | Tropical dry deciduous and thorn forest        | 3292                                |
| Bandipur (Johnsingh, 1983)                | Tropical dry deciduous forest                  | 3382 – 3619                         |
| Nagarhole (Karanth & Sunquist, 1992)      | Tropical dry and most deciduous forest         | 7638                                |
| Bardia(Dinerstein, 1980)                  | Tropical most with alluvial grasslands         | 2842 – 3120                         |
| Chitwan (Eisenberg & Seidensticker, 1976) | Tropical most with alluvial grasslands         | 2933                                |
| Kaziranga (Karanth & Nichols, 1998)       | Tropical most with alluvial grasslands         | 4252                                |

For Kaziranga, available density estimate was converted to biomass density by taking average weight of species from Eisenberg & Seidensticker(1976).

**Table 8.4 : Estimated tiger density (D) at four locations in India.**

| Location   | Tiger density (no. / 100 km <sup>2</sup> ) |              |
|------------|--|--------------|
|            | <i>D</i>                                   | <i>SE(D)</i> |
| Kanha      | 11.7                                       | 1.93         |
| Kazirangha | 16.8                                       | 2.96         |
| Nagarhole  | 11.5                                       | 1.70         |
| Pench      | 4.1  | 1.31         |

**Table 8.5: Large felid density and prey biomass relationship (Carbone and Gittleman 2002).**

| Predator | Average body weight | No populations sampled | No/10,000 km of prey biomass | no/100 km <sup>2</sup> | Prey biomass(10000kg/100 km <sup>2</sup> ) |
|----------|---------------------|------------------------|------------------------------|------------------------|--|
| Tiger    | 181                 | 6                      | 0.33                         | .7-15.34               | 4-89.54                                    |
| Lion     | 142                 | 21                     | 3.4                          | .8-38.5                | .01-116.99                                 |

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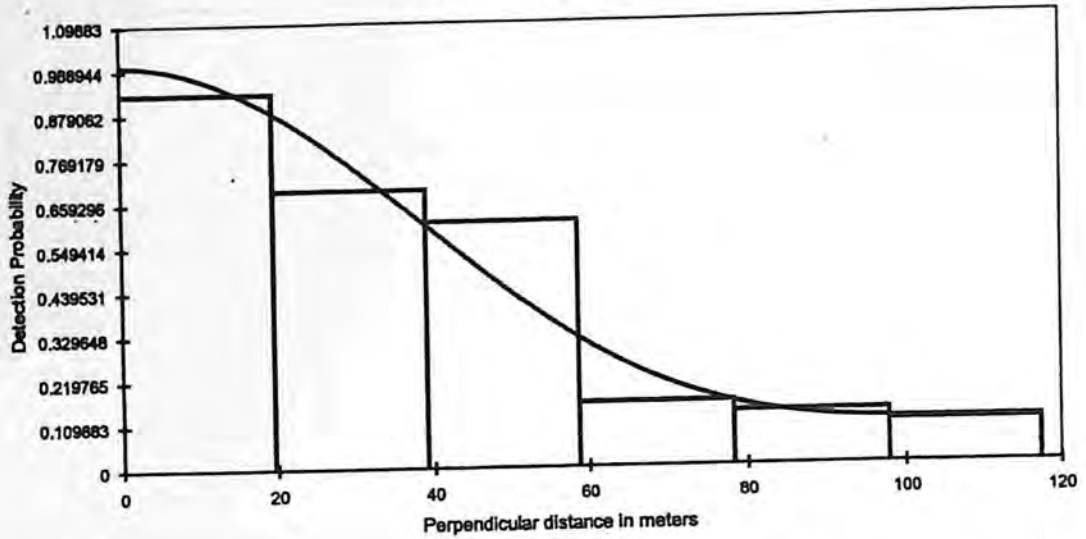
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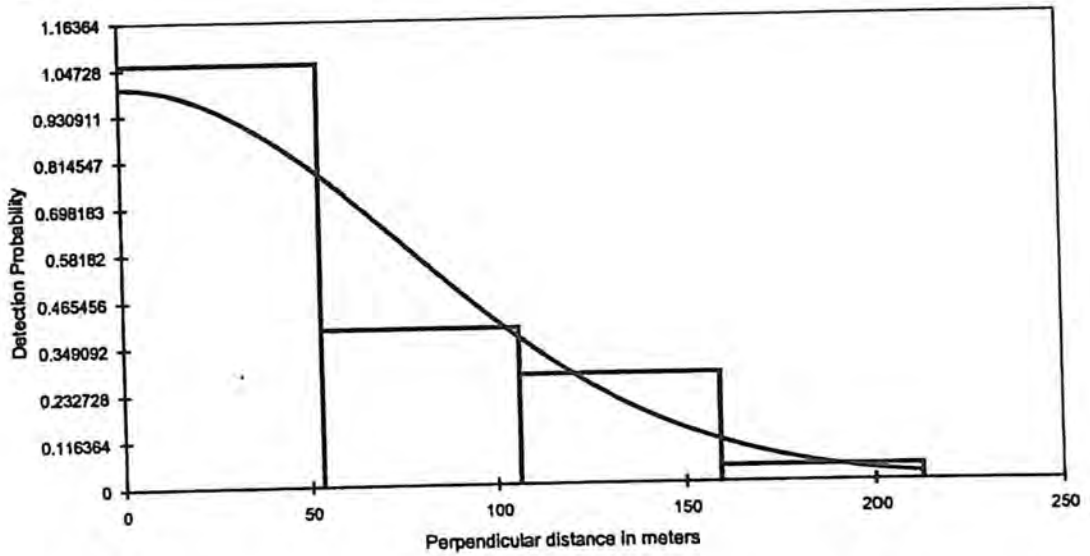
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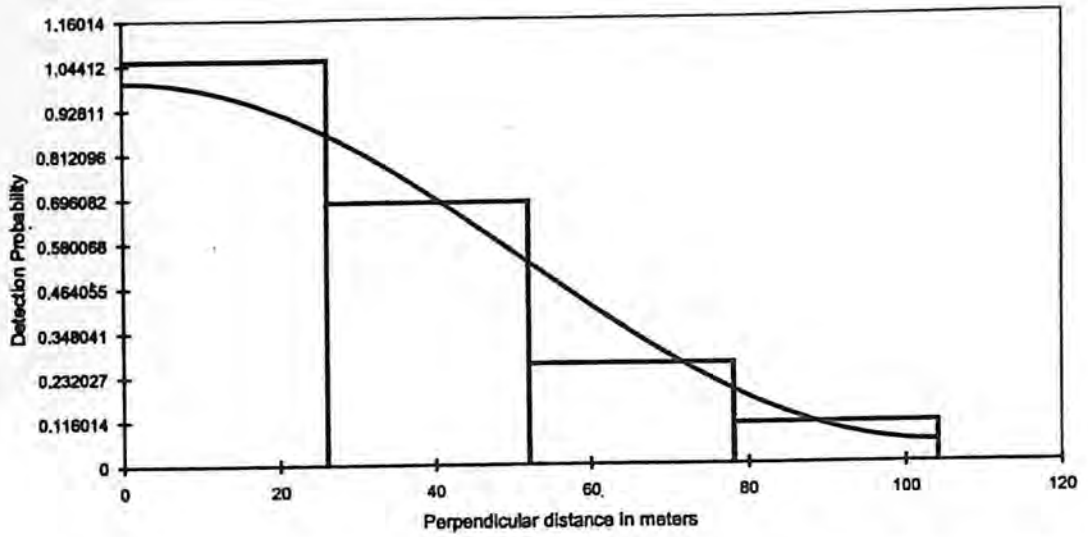
## ANNEXURE - I



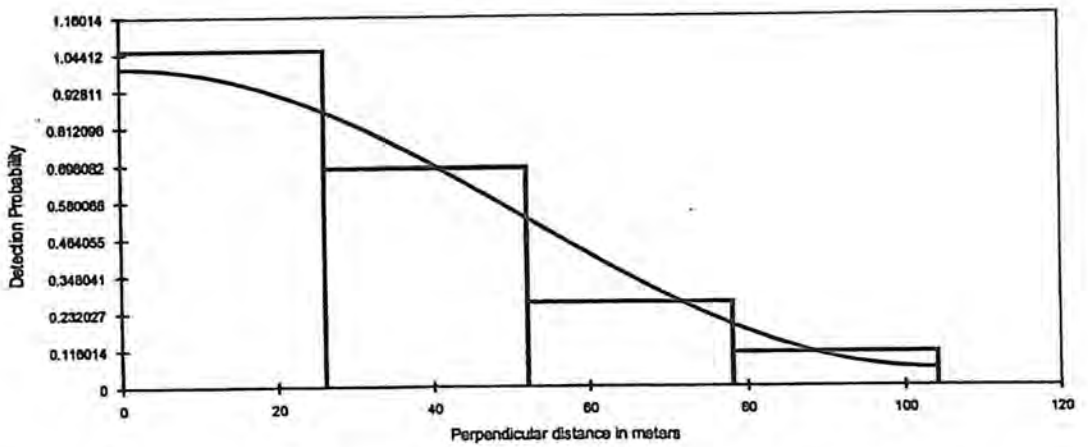
**Figure 1 :** Detection possibility for chital along line transects in Sariska Tiger Reserve, Rajasthan, November 2002-April 2003. Effective Strip Width: 51.47 m. (S.E 4.617)



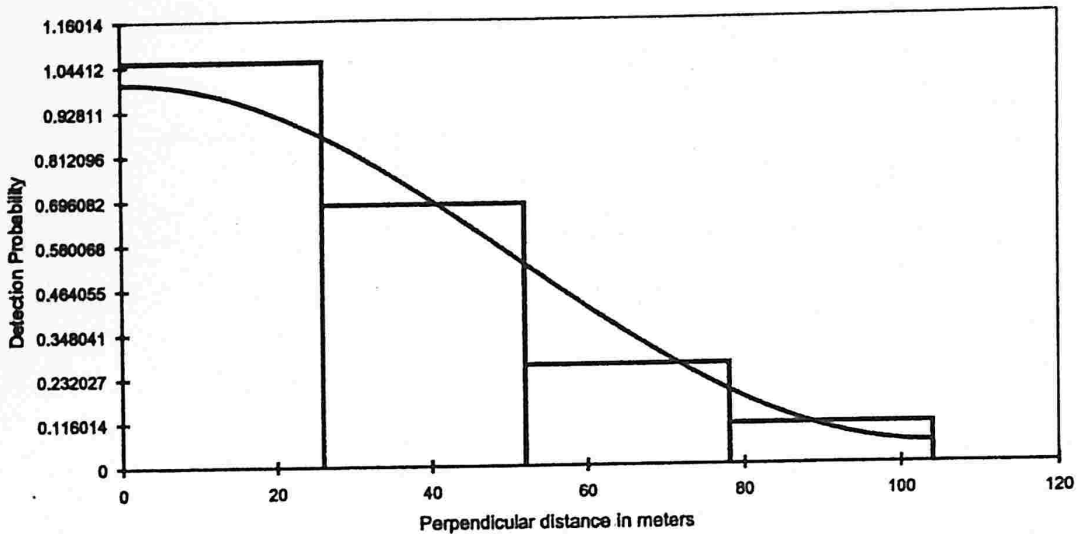
**Figure 2 :** Detection Possibility for cattle and buffaloes along line transects in Sariska Tiger Reserve, Rajasthan, November 2002 to April 2003. Effective Strip Width: 93.53 m.(SE 8.77)



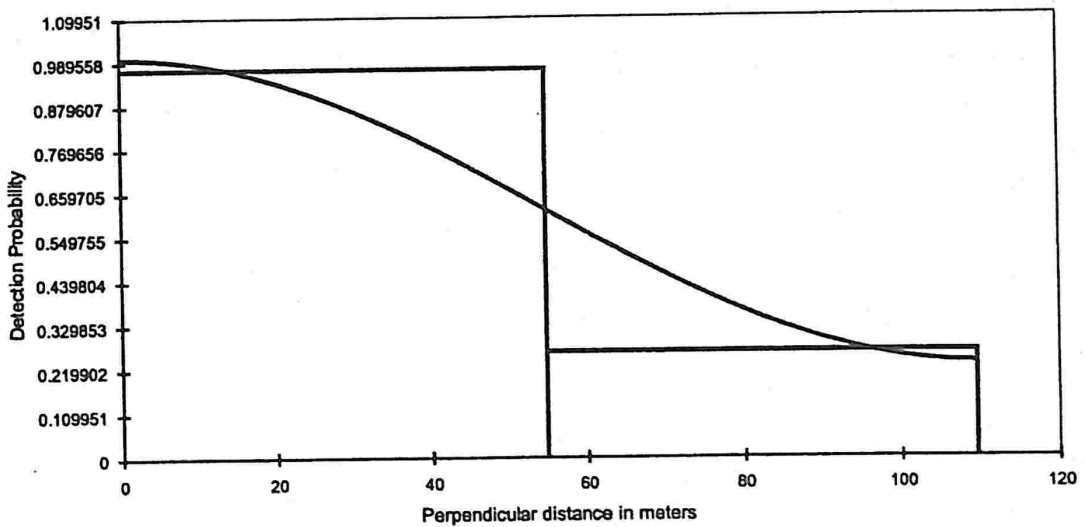
**Figure 3 :** Detection possibility for common langur along line transects in Sariska Tiger Reserve, Rajasthan, November 2002 to April 2003. Effective Strip Width: 54.915 m (SE 2.813)



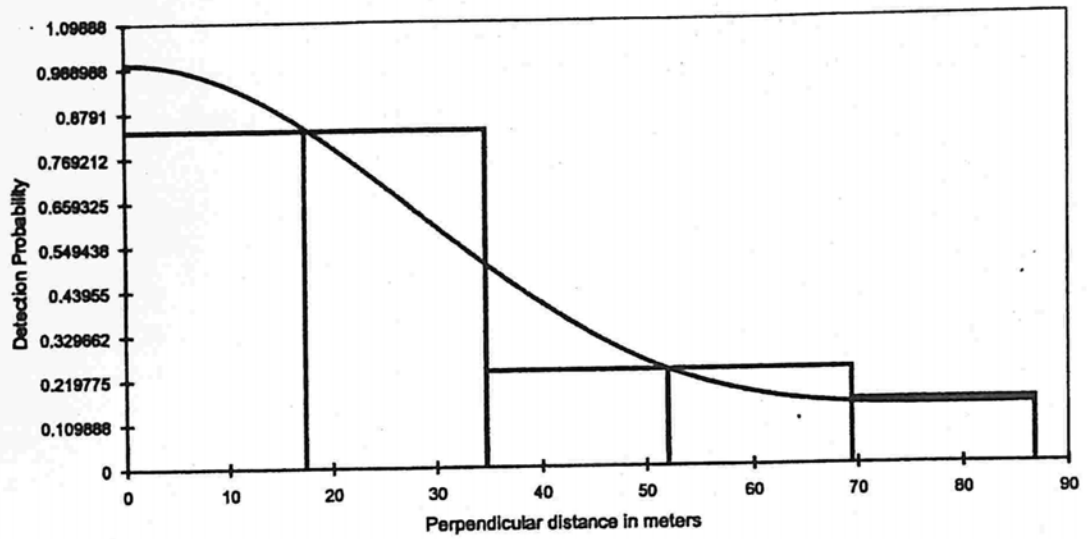
**Figure 4 :** Detection possibility for peafowl along line transects in Sariska Tiger Reserve, Rajasthan, November 2002 to April 2003. Effective Strip Width: 47.93 m (SE 3.543)



**Figure 5** : Detection possibility of nilgai along line transects in Sariska Tiger Reserve, Rajasthan, November 2002 to April 2003. Effective Strip Width: 66.64 m (SE 3.7222)



**Figure 6** : Detection possibility of wild pig along line transects in Sariska Tiger Reserve, Rajasthan, November 2002 to April 2003. Effective Strip Width: 67.75m (SE 0.518)



**Figure 7** :Detection possibility of sambar along line transects in Sariska Tiger Reserve, Rajasthan, November 2002- April 2003. Effective Strip Width: 40.01 m. (SE 5.085)

## ANNEXURE 2

**Table 1:** Sample size estimation to construct tiger diet based on scat data in Sariska Tiger Reserve (November 2002 to April 2003).

|              | Chital |     | Sambar |     | Nilgal |     | Buffalo |     | Cattle |     | Langur |     |
|--------------|--------|-----|--------|-----|--------|-----|---------|-----|--------|-----|--------|-----|
| Mean (Total) | 19.5   |     | 51.9   |     | 15.6   |     | 6.5     |     | 13     |     | 5.2    |     |
|              | Mean   | SE  | Mean   | SE  | Mean   | SE  | Mean    | SE  | Mean   | SE  | Mean   | SE  |
| (n = 10)     | 20.2   | 1.4 | 52     | 1.7 | 16     | 1.1 | 7.6     | 0.9 | 11.8   | 1   | 5.5    | 0.7 |
| (n = 20)     | 19.1   | 0.9 | 51.9   | 1   | 14.6   | 0.8 | 5.9     | 0.5 | 12.4   | 0.8 | 5      | 0.4 |
| (n = 40)     | 18.9   | 0.6 | 51.3   | 0.8 | 15.6   | 0.7 | 6.8     | 0.5 | 12.6   | 0.6 | 6      | 0.4 |
| (n = 60)     | 19.6   | 0.5 | 51.8   | 0.7 | 14.9   | 0.5 | 7.1     | 0.3 | 13.6   | 0.4 | 5.1    | 0.3 |
| (n = 77)     | 19.7   | 0.4 | 52.2   | 0.6 | 14.9   | 0.4 | 6.6     | 0.3 | 13.2   | 0.3 | 4.9    | 0.2 |