

**HABITAT UTILIZATION BY HOG DEER (*Axis porcinus*) IN RELATION  
TO OTHER SYMPATRIC SPECIES IN JALDAPARA WILDLIFE SANCTUARY,  
WEST BENGAL**

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**BY**

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# Habitat utilization by Hog Deer (*Axis porcinus*) in relation to other sympatric species at Jaldapara Wildlife Sanctuary



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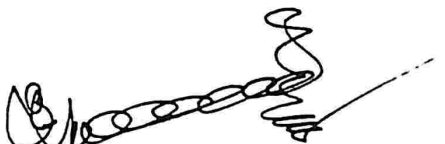
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## Certificate

This is to certify that Ms. Tanushree Biswas of the Wildlife Institute of India has carried out an original research work titled "**Habitat utilization pattern by Hog deer (*Axis porcinus*) in relation to other sympatric species in Jaldapara Wildlife Sanctuary, West Bengal**" in partial fulfillment of the M.Sc. (Wildlife Science) degree of Saurashtra University, Rajkot. This work has been carried out under our supervision from November, 1998 to June, 1999. We also certify that this research work has not been submitted for any other degree to any university.

  
(Dr. V.B. Mathur)

  
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**Faculty of Wildlife Management**

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## Summary

*This study on habitat utilization by hog deer (Axis porcinus) in relation to other sympatric species (chital & rhino) was carried out from December 1998 to April 1999 in Jaldapara Wildlife Sanctuary, West Bengal. The spatial and seasonal differences in habitat utilization of grasslands by hog deer, chital and rhino were investigated. The study was restricted to various types of grassland existing within the sanctuary which were broadly stratified into five major types: Pure grassland (natural), pure grassland (plantation), Savanna grassland (natural) and Savanna grassland (plantation) and riverine grassland.*

*Different habitats were traversed on riding elephants on selected paths to collect data on animal abundance/hr based on sightings in different habitat types. A total of nine transects were laid in different habitats to quantify availability of habitat parameters and their selection. Dung abundance was quantified using belt transects, at each 100m interval on the transects. The availability and utilization of habitats based on direct and indirect methods were examined using Neu et al (1974).*

*The results showed that hog deer selected areas with extensive grass cover with structural mosaics of cover and mostly early phenophase as opposed to habitats with low cover values. High abundance of hog deer were found in areas with higher proportion of Imperata cylindrica. Fire or burning of grasslands in combination with rain seemed to influence the overall selection of habitat by hog deer. Cutting of thatch by local people also influenced the habitat use by hog deer. Areas preferred by hog deer were found to have high cattle dung density thus showing a very high pressure on areas preferred by hog deer. Interaction with chital seemed to be very low as the areas preferred by hog deer are avoided by chital. Rhino also showed a similar trend with preference for plantation grassland areas and avoidance for natural grassland. Apart from the effect of these sympatric species directly, habitat use by hog deer seemed to have been influenced by the management steps taken to provide protection to Rhino. Plantation areas raised for the management of rhino were avoided by hog deer.*

## Chapter 1

### INTRODUCTION

Wild ungulates co-existing in the same habitat, exhibit a correspondingly heterogeneous distribution since they display varying degrees of habitat selectivity (Hirst 1975) with reference to resource use, space and time (Lamprey 1963, Rosenzweig 1981, Scogings *et al* 1990). The term habitat refers to an area that meets an animal's basic life requisites such as food, water, cover, and space (Giles 1978). A number of independent variables play a role in the formation of a particular habitat. An animal occupies or utilizes a habitat based on the spatio-temporal variation of such interdependent habitat variables (Norman *et al.* 1975). Most wildlife habitats are shared by more than one species. Even among two species occupying the same habitat there is a certain degree of temporal, seasonal and dietary separation in habitat use (Green 1987, Chakraborty 1991, Khan 1996, Sankar 1994). It is the identification of these separations for each species which helps in improved long term management and conservation of threatened animals and their habitats (Gilpin and Soule 1986, Seidensticker 1976), especially wild ungulates which form the prey base for many endangered and threatened large carnivores. Thus, a sound understanding of the habitat requirements of ungulates and habitat parameters affecting their distribution becomes very essential. Recently there have been studies on large ungulate-habitat interactions concentrating on the habitat components (Ben Shahr 1990, Fox *et al* 1989, Pratt *et al* 1986). However there have relatively been few studies in the Indian subcontinent notably among them being those by Schaller (1967), Eisenberg and Lockhart (1972), Berwick (1974), Dinerstein (1979), Mishra (1982), Green (1985), Karanth and Sunquist (1992), Haque (1990), Bhatnagar (1991), Mathur (1991), Khan (1993) Mishra (1993), Pendankar (1993), Sankar (1994), Sharma (1995), Bhat and Rawat (1995), Raman (1997) and Bhaskar (1997).

## 1.1 Review of literature on habitat utilization

Herbivores rarely have a uniform distribution (Pratt et al. 1986). Instead, they use habitats disproportionately more or less (prefer or avoid respectively) in relation to their availability. The basis for habitat selection studies is to relate the abundance of an animal to the features of its habitat (Patridge 1978). The extent to which a habitat can fulfill the animal's requirements determines habitat selection. In spite of the subjectivity in selection of habitat categories, it is possible to identify the important factors that affect the extent of use of an area by an animal (Ben Shahr 1990). In general, the habitat use by a herbivore is affected by factors such as abundance and quality of food, availability of water, suitability of weather, shelter against extremes of weather, availability of areas for escapes from predators, and human influence (Wilson 1981, Pratt et al 1986, Fox et al. 1989, 1992). Geist (1974b) and Jarman (1974) observed that the distribution of food resources in a habitat, the feeding behaviour and group size of the species, were interrelated. Jarman (1974) indicated that grazers which are largely non selective feeders, may be present in large groups as grass is abundantly available and grasslands can sustain high levels of grazing. Whereas, browsers are much more selective feeders, live in smaller groups or are solitary. Ungulates modify their activity pattern in response to habitat differences, seasons and disturbance factors (Owen - Smith 1982), and their behavior could be a sensitive indicator of habitat quality (Owen Smith 1982, Pachlatko and Nievergelt 1985). Therefore, knowledge about habitat requirements of a species and their use are essential to enhance effective management of the species (Eisenberg and Seidensticker 1976, Riney 1982).

The importance of availability while determining habitat selection has long been recognized (Glading et al. 1940, Neu et al. 1974). A study on big horn sheep found that the animals did not use >20% of the available range (Krausman and Leopold 1986). Neu et al (1974) analyzed the habitats used by moose (*Aces alces*) in Northern

Minnesota in relation to their availability and found that the animals preferred peripheral burnt habitats and avoided the center burn and unburned habitats. Irwin (1975) reported results similar to Neu *et al.* (1974) in the same study area for moose as well as white tailed deer (*Odocoileus virginianus*) and explained that habitat preference was related to the presence of preferred forage.

Forage seems to be an important determinant of habitat use by herbivores. Seasonal changes in forage quality cause shifts in habitat use (eg. Klein 1970 in Schaller 1977, Pratt *et al* 1986, Dinerstein 1987, Gordon 1988). Plant species distribution and phenology are affected by features such as water table, soil moisture, soil nutrient, geology and porosity of the area. These habitat components have an influence on forage quality, and consequently on habitat use (Schaller 1967, Elsner Schack 1985).

Anti-predator strategies may have an overriding importance in determining herbivore habitat use. Fiesta-Bianchet (1988) concluded that anti-predator strategy of pregnant bighorn ewes (*Ovis canadensis*) prevented them at certain times from using the habitats with best forage. Goat (*Capra sps.*) and sheep (*Ovis spp*) inhabit open areas and show gregariousness as an anti-predator strategy (Geist 1985) which enhances early detection of predators. On the other hand, hog deer (*Axis porcinus*) requires a habitat that provides ample escape cover when threatened, they take refuge in thick vegetation (Dhungel and O' Gara 1991). Thus, presence of quality forage and areas for escape seem to be of paramount importance in determining ungulate habitat use patterns.

This study concentrates on the habitat utilization of hog deer (*Axis porcinus porcinus*), an obligate species of grassland in Jaldapara Wildlife Sanctuary. Hog deer in Jaldapara occurs in sympatry with the Great one horned rhino (*Rhinoceros unicornis*), elephant (*Elephas maximus*), gaur (*Bos gaurus*), chital (*Axis axis*), sambar (*Cervus*

*unicolor*) and barking deer (*Munitacus munjac*). Among all the species above hog deer is expected to have maximum overlap in terms of habitat utilization in grassland with chital, rhinoceros, and elephant. However, elephants in Jaldapara are mainly of seasonal occurrence and hence it was not possible to quantify the influence of elephants on the habitat utilization of hog deer. The main objectives of this study are discussed in later sections.

## 1.2 Coexistence among deer

The deer family has evolved primarily as a group of species of forest or forest edge, in practice show a wide variety of adaptation to different habitats. While many modern species remain woodland animals, some have become adapted to other kinds of ecosystems, colonizing such specialized environments as swamps or marshy lands (Moose, Barasingha and Thamin) or, like the pampas deer, of south America or hog deer of Asia, secondarily adapting to life in open grasslands. Still among woodland species, we can see clear evidence of specialization to particular kinds of woodlands preferred for particular woodland structure. Some species favour dense forests other open woodlands or forest edges. Very few are complete opportunistic and it is usually possible to define for any species quite a narrow range of conditions in which it may be found. The clearest illustration comes from the situation where a number of deer species share their environment not only with predator species but with a whole variety of other animals, many of which may be potential competitors, intensely competing for food and/or other resources and may have a major impact on population performance or ecology of others.

Intense competition in terms of habitat selection exerts a powerful pressure, and may result in change in behavior or ecology of other species, either through immediate change in the behavior of the animal or in the long term, through evolutionary change within the species. But in either case use of slightly different

spectrum of resources in order to reduce the level of competition is evident. In most cases deer share their resources with a variety of other large ungulates. Yet differences do exist in the habitats favored by different species, and subtle differences in habitat preferences do seem to separate them from each other. In European forests for e.g. red deer, roe deer, fallow deer, and where introduced Sika deer all occur together in one locality. In South Central Asia, chital, Sambar Hog Deer and Indian Muntjac (barking deer) occur together; in the forests of central and south America four species of Brocket deer have overlapping ranges. In each case, closer examination reveals that every species has its own distinct habitat preference, and performs at its best in subtly different set of conditions from those which suit others. In most cases competition in the past, or the potential for it, has led to the evolution of a high degree of ecological separation, so that each species has already become specialized to a different niche, to use a different set of resources within the system, specifically to avoid competition (Putman R.J 1988). Thus, wherever a number of species co-occur within a given geographical region, they will differ markedly in the habitats occupied or will be specialized to exploit different type of food. Hanley (1984) showed that black tailed deer and wapiti during the summer months separated out quite clearly in ecological habit and were unlikely to compete. Similarly Jenkins and Wright (1988) concluded that overlapping distribution and habitat use patterns coupled with resource limitations suggest a high potential for interspecific competition between wapiti, white tailed deer and moose.

### **1.3 Justification for this study**

This study is designed with the perspective of conservation and management needs of hog deer (*Axis porcinus*) a species not yet listed as endangered. But in consideration to its distribution along the flood plain grasslands and the dramatic loss of such habitat during the last few decades raises some serious questions about its

status. This study specifically aims in determining its habitat requirements in terms of differential use of various forage and cover in presence of sympatric species, chital (*Axis axis*). These grasslands are also occupied by the mega herbivores like one horned rhinos and elephants. In spite of the presence of these herbivores the resource utilization pattern of hog deer is more governed by the inter-specific association with chital than rhinoceros or elephants, since they are more closely related and may influence the resource use by each other. On the other hand rhinos, elephants in general will have an impact on habitat use by small bodied ungulates. It is evident from other studies (Schaller 1967, Putman 1988, Sankar 1991, Mishra 1982, Mathur 1993, Dubey 1999) that chital is a more generalist species i.e., both grazer and browser whereas the hog deer is an obligate grassland species. Among all others sympatric species found in JWLS rhino is the only other obligate species of grassland other than hog deer. So, rhino may be the other species which might strongly influence the resource use by hog deer. Several studies have speculated the threat of serious decline of grasslands due to intrusion by woodland succession, changed community, increase of unpalatable species, loss of nutrients and change in productivity. In Royal Chitwan National Park, Nepal Mishra (1982) has studied the habitat use by chital, sambar, hog deer and barking deer occurring within the park. The habitat or vegetation communities included grasslands, riverine forests and sal forests. During his study over three years it was found that 75% time chital spent in riverine forest, 23% in grasslands and 2% in sal forests, whereas in the case of hog deer (a grassland specialist) as stated earlier 95% of all observations were made in open grasslands. Schaff (1978) has recorded similar separation in use of different grassland types between chital, hog deer and barasingha in another area of Nepal. Though chital is a generalist species many studies have shown that chital is by choice a grazer and grasses contribute about 75% of its diet. Thus competition at some level is speculated to exist between them. However we don't have any scientific study or

evidence to support our assumption. In a geographically similar situation, in the Corbett Tiger Reserve, Tak and Lamba (1981) had reported the existence of competition between hog deer and chital for food and space. While a potential for competition may exist in this case but in natural systems, evidence of competition is hard to prove. In most cases evolution over many generation has established the separation or specialization that we observe now. Thus the conclusion by Mishra (1982) that four species of deer ( hog deer, chital, sambar, barking deer) co-existing within the Chitwan National Park, Nepal with distinct habitat preferences and diets with less likelihood of competition may be a result of 'Ghost of past competition' (Putman 1988).

In this study an attempt is made to generate baseline information on the comparative use of various habitat by hog deer and chital which will later help us in exploring the possibilities of competition between them. Here by habitat we mean the various types of grasslands found in JWLS and their comparative utilization by hog deer and chital. JWLS lies in the terai region where the grasslands are in seral stages of succession apart from being under stress due to habitat degradation. The grasslands in Jaldapara have many unpalatable coarse grasses and there are evidences of weeds such as *Leea* spp. , *Eupatorium* spp., and climbers (*Mikania* spp) species invading and encroaching into these grasslands. The park has also lost extensive areas of best grasslands of older channels of Torsa river (Torsa, and Jaldapara-2,4,and 5 comp.) as there is insufficient flooding of these grassland and due change of river course of Torsa in the floods of 1968 (Pandit 1996). As a result of this, vegetation pattern of Jaldapara (2,4 and 5) and Torsa block is changing gradually. So some artificial intervention is called to maintain these grasslands. One such well defined tool used to maintain these grasslands is prescribed burning (Svejcar 1989). Though burning is known to act as a tool for maintenance of these grasslands it is important to know how do the organisms depending on grasslands respond to such practices. ?; how does burning influence the ecological relationship between two sympatric species ?

During my study period it was found that 95% of the cases of burning are illegal in origin. It seems that every year the grasslands are burnt by the villagers either for thatching or cattle grazing. Though this burning also helps in maintenance of grasslands it creates a tremendous stress on wild animals since the burning is irregular both in time and space resulting in sudden loss of total cover and forage. It also modifies the species composition and structure, and changes the moisture gradient of the soil hence influencing species composition. The interest in species composition and structure needs to be clearly set out e.g., palatability, weed abundance, loss of perennial vis-a-vis gain in ephemerals, sensitive vs. fire resistant species, changes in species of conservation importance (McNaughton 1992). Since hog deer is an obligate species of grassland any pressure on the grasslands either due to some management practices or natural processes will be more detrimental to them as compared to chital. Thus there is a need to design a proper burning practice in conjunction with plantation activity so that it does not induce or increase the pressure on hog deer. Basic information on how a common resource : grassland is used by both the species is required

However the other major practice followed at JWLS to maintain these grasslands is plantation of fodder species to sustain the population of a mega herbivore, the rhino. Fodder species like Dhadda, Malsa, Madhwa, Ekhra (Different species of *Saccharum*) Nal (*Arundo donax*), Khagra (*Phragmites Karka*) and short grasses like *Cynodon dactylodon*, *Paspalum*, *Vetiveria*, *Chrysopogon* etc. are planted in between tall grasses under the new management plan. Thus it is also important to know how these areas of plantations are affecting different species. Keeping all these question in mind I have tried to answer some specific questions which may later help in generating information about better management of these grasslands and its fauna.

## 1.4 Objectives of the study

The main objective of this study were to determine

1. The habitat utilization pattern by hog deer in relation to other sympatric species.
2. The habitat requirements of hog deer
3. How the variation in availability of habitat variables affected the habitat selection by hog deer.

Common null hypothesis tested to achieve these objective is that hog deer used the habitat variables in proportion to their availability. Since the null hypothesis was same except for the different variables so they are not stated separately.

## Chapter 2

### Study Species

#### 2.1 Introduction-----An over view of Hog deer

The deers belonging to the genus *Axis*, chital and hog deer, are considered by Flerov (1952) to be among the most primitive of the true cervids, having been present during the Pliocene and Pleistocene in Europe and Asia (Matthes 1962). Lydekker (1913-16) regarded *Axis* as a subgenus of *Cervus*, but Simpson (1945) raised *Axis* to generic ranks, a classification followed by Ellerman and Morrison Scott (1951) since it differs in a number of ways, especially the presence of pedal glands in the hind feet (but not in the fore feet also as in *Dama*).

#### 2.2 Hog deer (*Axis porcinus*) (G. Kenneth Whitehead<sup>1)</sup>)

##### 2.2.1 Morphology

Hog deer (*Axis porcinus*) also taxonomically named as *Cervus porcinus* Zimmermann (1777) (Hill and Corbett 1992), is a much smaller animal and a species that has left woodland for tall grasslands or 'grass jungles' (Putman 1988). The hog deer is heavy set and compact, standing only 27 to 28 inches high at the shoulder (Prater 1980)). Its chunky appearance and habit of crashing away through the undergrowth have undoubtedly contributed to its popular name. The antlers are about 10 to 15 inches long, 3-tined and set on tall pedicels. The winter coat is dark brown, the summer one chestnut brown covered with faint to conspicuous white spots, the fawns are spotted.

##### 2.2.2 Distribution and Habitat

There are only two subspecies of hog deer found all over the world : *Axis porcinus porcinus* and *Axis porcinus annamiticus* (Whitehead 1972, Putman R.J 1988, Dhungel & Gara 1991, Hill 1992). *Axis porcinus porcinus* is restricted to Sri Lanka and the low alluvial grasslands of the Indus and Ganges valleys, where it ranged from Sind in the west (67° E) through Punjab, UP, Bengal to Assam in the East and thence to Burma

24° lat. The Himalayan foot hills mark the extent of its range south and north respectively in India. About the distribution, Dollman and Burlace (1935) have stated that the species is not found in Central and Southern India (Schaller 1967, Prater 1980). The latter species, a slightly larger race is found further south in Thailand. Males stand about 65-75cm at shoulder (with females slightly smaller at 60-65 cm) and weigh 35-45 kg (Prater 1934, Mishra 1982, Putman 1988). However the present range of Indian subspecies is confined only to the grasslands in terai region of Uttar Pradesh and Assam i.e. the floodplains of the Ganges and Brahmaputra (Spillett 1966). Its preferred habitat is the reed beds and swampy meadows bordering streams (Peacock 1933), extensive forests being generally avoided (Schaller 1967, Mishra 1982). In Corbett National Park they were observed occasionally in the valley of the Ramganga river but not in the surrounding hills; in the west Kheri they were common on the low lying marshy meadows bordering the sal forests and in Kaziranga Sanctuary they were abundant in the vast grass thickets (Schaller 1967).

### 2.2.3 Behavior

Unlike chital hog deer is said to be less social and essentially, solitary, collecting at times into groups of 2 to 5 individuals (Peacock 1933, Prater 1980) but never into herds (Lydekker 1898, Whitehead G. Kenneth 1972). But a maximum of 40 individuals and more (Ghosh 1997) were observed in Kaziranga Sanctuary by Schaller (1967). Such herds never moved or fled as co-ordinated units and when disturbed the animals scattered in all directions. Although hog deer are solitary they appear in groups at the time of rutting and at certain feeding sites (Schaller 1967). Their food consists mainly of grasses, leaves and young shoots (Whitehead 1972, Mishra 1982).

The sex ratio of adult hog deer favored the does only slightly in contrast to Chital which has a sex ratio skewed towards females. According to Prater (1934), Blanford (1888-91) and Lydekker (1898), the rut of the hog deer occurs during September and October after a gestation period of 8 months (Sclater 1836, Lydekker 1898), the

fawns are born in April and May (Prater 1980). Schaller (1967) also has evidence of fawns born in the month of February. The rut of Hog deer in UP seemed to start from around June and lasts till January with the peak in the month of September and October.

### 2.3 Feeding ecology of chital, hog deer and rhino---- Importance of grasslands for hog deer

Deer in terms of feeding ecology are classified into browsers, those which predominantly feed on woody materials and leaves of trees and shrubs and as grazers, those which feed primarily on grasses and herbaceous vegetation. Another classification of deer as concentrate selectors, bulk feeders or intermediate (Hofmann 1973) describes their foraging habit depending upon gut structure and morphology. One can determine feeding style of any deer species from its gut structure (Hofmann 1985) or the composition and activity of its ruminal symbiont. Four chambered stomach of cervids for fermenting food (Eisenberg and Lockhart 1972) and limited capacity for storing food in the rumen sets a limit on the feeding rates of ruminantes (Geist 1974, Jarman 1974), which may be important in periods of scarcity of food (Bell 1983). when the scope of competing with each other is high. Primitive species with small body size have higher calorific requirements with high metabolic activity, while in case of the bulk feeding mega herbivores like rhinoceros and elephant, the need for continuous supply of food, especially in consideration to the calorific value. Geist (1974) and Jarman(1974) also indicated that grazers which are largely unselective feeders may be present in large groups as grass is abundantly available and grasslands can sustain high level of grazing pressure, whereas, browsers which are more selective, live in small groups or are solitary in behaviour. Also small bodied species like hog deer have higher metabolic rate and hence require a higher protein diet whereas larger species like chital can survive on coarser food. However gut structure is not the only thing to determine the diet of a species. Species which have to feed selectively tend to have

narrower heads and muzzels than do bulk grazers of equivalent body size enabling them to select more precisely (Gordan and illius<sup>7</sup> 1988, de Stenev bie 1988).

Rodger's (1988a) identified four feeding styles in Indian wild ungulates. Primary grazer, selective ground layer feeder, generalist and primary browsers. A strong relationship exists between body size, rumen-reticular volume, mouth part size, and diet. As there is no specific study or information on the diet of hog deer in relation to its size, structure of mouth parts and rumen volume, it is difficult to classify them either as browser or grazer. But compared to the size and morphology of chital it could be presumed to be a grazer and specialist species of grasslands which also supports Mishra's (1982) 95% of observations of hog deer in grasslands.

## Chapter 3

### Study Area

#### 3.1 Location

Jaldapara wildlife sanctuary has been placed on the wildlife map of India because of the presence of the great Indian one horned Rhinoceros (*Rhinoceros unicornis*). The sanctuary is located in the flood plains of river Torsa and other small rivers, which have created large tracts of grasslands sustaining a small population of one horned rhinos.

Jaldapara Wildlife sanctuary lies in the civil district of Jalpaiguri, West Bengal, which is situated between the latitudes 25°.58" and 27°.45" North and longitudes 89°.08" and 89°.55" in the east (Plate 3.1).

#### 3.2 History

The forest of the sanctuary were being managed for commercial purpose till 1929 as part of the Buxa Forest Division. The Bengal Rhinoceros preservation act came into force in 1932 providing protection to the one horned Rhino. The area was declared a "Game Sanctuary " in the year 1941. The Game sanctuary was renotified as Jaldapara Wildlife Sanctuary in 1976 under section 18-b of the Wildlife Protection Act, 1972 and its area was increased to 115.53 sq.km.

#### 3.3 Significance of the sanctuary

Jaldapara Wildlife Sanctuary contains one of the largest tracts of Savannah grassland now left in West Bengal although large parts of the said grasslands have been lost due to extension of agriculture or other development activities. Savannah grassland of Jaldapara harbour some important grassland dependent fauna such as

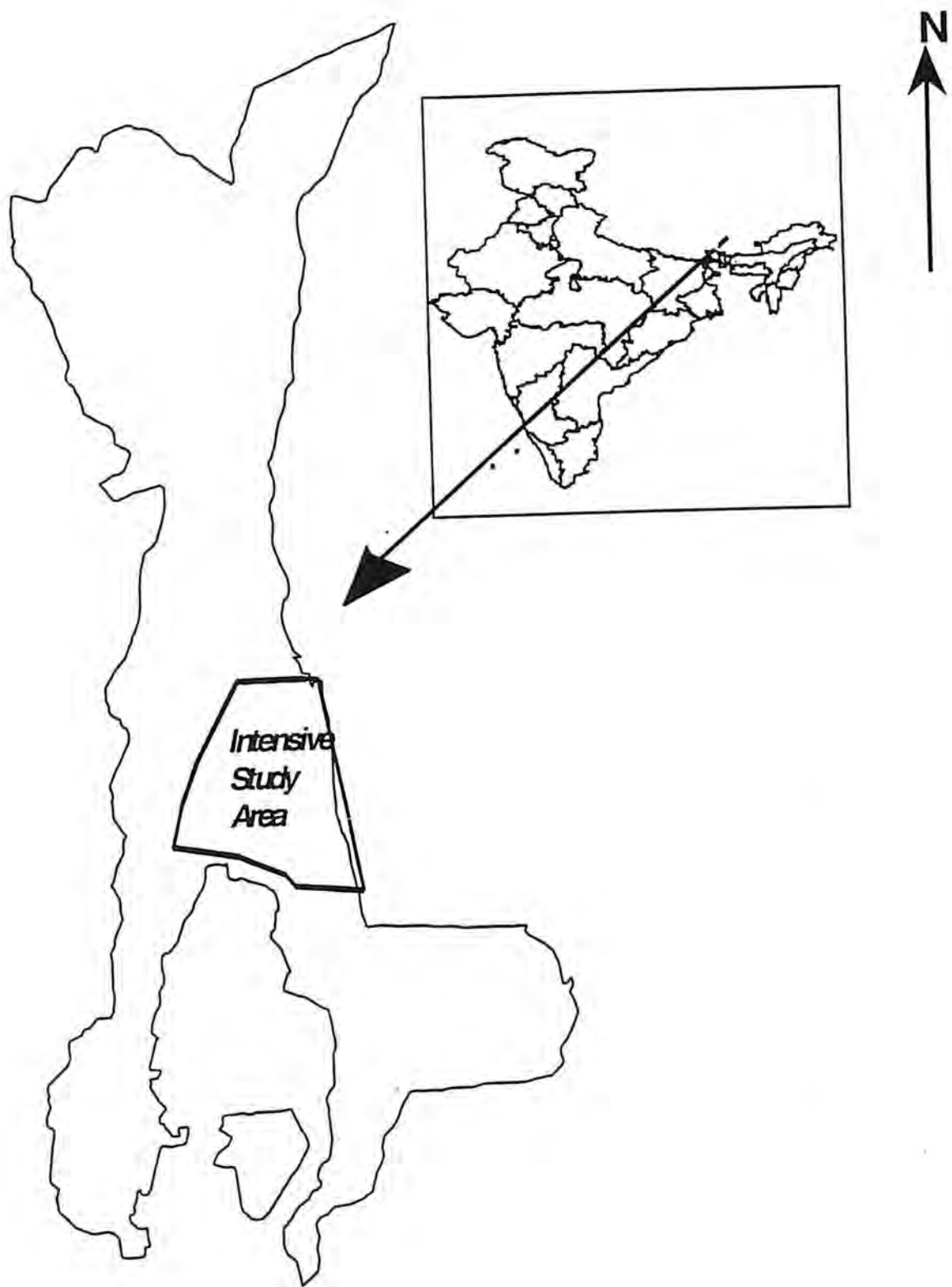


Plate 3.1. Boundary Map of Jaldapara Wildlife Sanctuary with Intensive Study Area marked ( $\approx 5 \text{ Km}^2$ ) ( Scaled 1: 50,000).

rhino, hog deer, hispid hare, and Bengal florican. Swamp deer and wild buffalo existed in the sanctuary are now extinct.

### 3.4 Geology, rock and soil

The geological formations normally encountered in this tract are of sub-recent to recent origin and comprise of the following:

1. Alluvial formation: It is mainly represented by silt and clay without much gravel or boulder and constitutes the flat plains to the south, under extensive cultivation, outside the sanctuary.
2. Terai formation: This formation characteristically occurs between the alluvial formation to the north and bhabar formation in the south. It is better stratified and has significantly more clay than in the bhabar formation.
3. Bhabar formation: This formation is represented by loose gravels, boulders and river deposits that are highly variable in composition and texture. This is also known as older alluvium. Surface data indicate that clay is mixed in varying proportion and clay beds cannot be clearly distinguished. Except during monsoon, the formation is apparently devoid of water and the streams carrying volumes of water disappear in the porous structure of the formation and reappear towards south in form of springs.
4. Ground water resources: Since most of the area is covered with loose sand and gravel, there is considerable potential for the development of ground water in the region. Ground water occurs both under water table conditions as well as in deep aquifers. Slope of water table is generally parallel with the surface slope, which is southwards. At places, the water table slope intercepts the ground surface forming springs.

### 3.5 Terrain

Configuration of the sanctuary is more or less flat and the elevation varies between 60 to 130 m except for Titi reserve forest which is in the hills, steep and precipitous, having elevation ranging from 152m to 610m MSL.

### 3.6 Rainfall and Climate

1. Rainfall: Jaldapara lies in the moist tropical zone, and the rainfall is monsoonal. The average annual precipitation is approximately 382 cm for the last 11 years. South West monsoon is the main source of rainfall. Maximum rainfall occurs from mid June to September, July and August are the wettest months. March receives the maximum of winter rainfall. December is the driest month with minimum rainfall. Pre monsoon showers accompanied by hail occur in the months of April and May. However during my study period there were no winter rains and pre monsoon had set in by mid April.

2. Temperature: The average day temperatures generally vary between 10°C to 21°C from November to February and between 27°C to 37°C during May to September. In Duars, there is an appreciable variation between day and night temperatures throughout the year. During the months from June to September, moist heat that prevails during the day time and early part of evening is oppressive but the nights are usually cool.

3. Humidity: Since the sanctuary is located along the foothills of the outer Himalayas, it remains adequately humid throughout the year. Maximum relative humidity varies between 80%-95%, seldom below 75% with a maximum in June to September and minimum in December to February.

### 3.7 Rivers and streams

Jaldapara is located in a level flood plain, 200 feet (61 metres) above sea level. The sanctuary is intersected by numerous rivers and streams flowing from North to South. The important river that flows through the sanctuary area is Torsa rising and falling with great rapidity and changing its courses frequently. It becomes shallow and tame during dry season and remains full and fierce during rains. The river beds are continuously rising as a result of deposition of a large quantity of silt and detritus material from the hills. The Torsa originates in the Chumbi valley of Tibet where it is known as "Machu" then it flows through Bhutan and enters India, ultimately draining into river Brahmaputra. It is dynamic in its flow and has different channels over a tract of about 20 Km width from east to west, by shifting its course from time to time during the last one and half century. As a result the whole tract comprises a network of streams and channels. Some are current and some are not active but all are recognized as Torsa. Torsa has a perennial flow throughout the year. Malangi and Kalijhora were a small river but at present they have merged completely with Torsa during these recent floods in 1993 and 1998. The next most likely river or perennial stream to merge with Torsa if there's a severe flood or rain is Sisamara.

### 3.8 Flood

Streams in this region have a tendency to cut channels during the annual flood season, from May to September. They intercommunicate by network of cross-country watercourses. Floods of severe nature, that deserve mention on account of damage caused to the forest, took place during 1952, 1954, 1968, 1993 and 1998. Of these 1968 flood is considered to be a land mark since these resulted in a total change in the course of river Torsa. Before this flood, the main flow of the river Torsa was in the western arms of the sanctuary. But on account of silt deposition after flood, this channel of Torsa was completely blocked up and the entire flow of the river entered the

Siltorsa constituting only one course. During the flood of 1998 there was quite a severe damage done to the forest. Since most of the high density rhino areas and parts of high forest were washed away.

### **3.9 Fire**

Earlier prescribed burning was a common practice employed by the department till 1966. The forest department maintained 20 miles (322 km) of 50-foot (15 m) wide fire lines within the sanctuary. These were comprised of 12 lines, mostly running from east to west. These lines were intended to protect the area against unplanned fires or to provide a means by which prescribed burning can be controlled and systematically applied for management purpose. The sanctuary was burned annually by a controlled rotation method. Alternate blocks were first burned. The unburned blocks were used as cover and provided forage for wild life until new growth in the burned areas was sufficient to provide these necessities. Then the remaining blocks were burned by the sanctuary staff. However no such practice is followed at present and 80% of the incidence of fire are unplanned and attributed to villagers. Spillette (1966) had quoted "...what was once a predominantly forest area is gradually becoming a savanna or grassland due to annual burning..." seems to have taken the natural course of a woodland climax in many parts of the sanctuary. Given protection over time it seems that many grassland patches are exhibiting succession and shifting the grassland community towards a woodland climax, with intermediate stage of woodland savanna seen most commonly.

### **3.10 Plantations**

Since several of the grasslands are being lost to the savanna woodlands, it is resulting in decrease in quality and quantity of the former. Therefore some artificial plantations are done in order to sustain the grassland habitat of the rhino. Raising

plantation of major fodder species preferred by rhino is a most common practice applied in many parts of the sanctuary to provide food and cover to the species which is threatened with local extinction. Since the sanctuary is managed primarily for the one horned rhinos, the objective is to maintain or create necessary habitat conditions for this species. Existing grassy areas, which are considered best habitat for the rhinoceros are generally being invaded by the tree species like sissoo, simul etc. as a result of successional progression. To arrest such development, cutting back of the trees is being undertaken as an experiment. The coppice shoots that come up, particularly from the sissoo trees are reportedly favored as food by rhinoceros.

### 3.11 Vegetation

The sanctuary lies in the biogeographic cal zone 7B (Lower gangetic plain) as classified by Rodgers and Panwar (1988). Generally the entire forest in J.W.L.S falls under the north Indian moist tropical forests of Champion and Seth's recent classification (1968). The species which is most commonly found within the forest and is of importance from the economical and ecological standpoint is sal (*Shorea robusta*). This species usually occurs in association with chilauni (*Schima wallichii*), chikrasi (*Chirkasia tabularis*), champ (*Michelia champaca*) and bahera (*Terminalia belerica*).

The other important species that are commonly seen are sidha (*Lagerstomia parviflora*), panisaj (*Terminalia myriocarpa*) lampati (*Duabanga sonneratiodes*), lali (*Amoora wallichii*), lahsune (*Amoora rohituka*), kainjal (*Bischofia javanica*), simul (*Bombax ciba*), khair (*Acacia catechu*), sissoo (*Dalbergia sissoo*) and siris (*Albizzia spp.*).

There are three distinct types of savannah forests recognised by Champion and Seth in this area:

1. Moist Sal Savannah (3c/DS1) is characterized by the presence of scattered sal along with kumbhi (*Carea arborea*), amloki (*Embllica officinalis*), Sidha, Tanki etc. The

predominant grasses are *Saccharum* species, *Arundo donax*, *Phragmites karka*, *Imperata cylindrica* and *Themeda arundinacea*.

2. Low alluvium savannah woodland (3/1S1) is characterized by *Bombax* – *Albizzia* association. This type is met within the riverine flats that tend to be flooded during the rainy season but dry out during rest of the year. Jaldapara is a typical representative of this type where *Simul*, *Siris* and other important species like *khair*, *kainjal* and *pitali* (*Trewia nudiflora*) appear as associates. Grasses are very dense, sometimes 4-5 m high and comprise of *Saccharum procerum*; *S. spontaneum*, *Phragmitis karka*, *Arundo donax*, *Themeda arundinacea*, *Imperata spp.* etc.

3. Eastern alluvial grassland (4D/2S2) is found in patches inside the sanctuary where like the previous type the tract is deeply flooded during monsoon and becomes completely dry in summer months and soil becomes hard. The alteration of moisture conditions seems to inhibit any tree growth and has resulted in pure grassland on the banks of river Torsa. The grasses found here are *Saccharum spontaneum*, *S. procerum*, *Erianthus arundinacea*, *Phragmites karka* and *Arundo donax*.

The grassy tracts occurring on the riverine formation are the associates of primary succession. The savannah types described in earlier paragraphs bear a great deal of resemblance to these . Only their origin, composition and development help us to distinguish one from the other. The savanna has often resulted due to change in the course of the river following flood and deposition of sand which completely altered the standing vegetation and brought about drastic edaphic changes to encourage grass growth once again. The striking example of such reversion to grassland is clearly demonstrated in some parts of *chilapata*, *lankapara*, *nilpara* and *jaldapara* ranges.

There often are changes in the course of the rivers following flood and a new deposition of gravels and sands take place over the standing vegetation along the river banks. This condition causes destruction of older seral stages and brings about a

complete edaphic change where some pioneer tree species and grasses colonise the new deposits. Here the soil is very porous and dry during summer and is almost devoid of humus. Grasses are mainly dominated by *Saccharum spontaneum*, *Bothriochloa pertusa*, *Apluda mutica*, *Vetiveria zizinooides*, *Chrysopogon aciculatus*, *Pennisetum glaucum*, *Setaria intermedia*, *S. palmifolia* and others in association with almost pure formation of *Dalbergia sissoo*, *Acacia catechu* and a purple flowered herb *Exacum tetragonum*. This type is found in some part of Chilpata, Madarihat, Jaldapara and Malangi blocks of the sanctuary.

In some places on the river bed only kush grasses are found but gradually *Saccharum* spp. are replacing the Kush, in areas where soil formation has improved. Kush is found just on the both sides of river bed and on islands within the river. Obviously the area is sandy and gravelly. Due to formation of soil primarily *saccharum* grasses are coming up in patches and gradual takeover of *simul* in tracts with more improved soil. In due course, if these areas are not disturbed, they will automatically be transformed into woodland savanna with *sissoo*, *simul*, *khair* as principal tree species. It has been observed that these areas are utilized by rhino and other herbivores also.

### 3.12 Fauna

The Sanctuary is endowed with faunal diversity typical of this region. There are mega herbivores like Elephant (*Elephas maximus*), Great One horned Rhinoceros (*Rhinoceros unicornis*), Gaur (*Bos gauras*). Other ungulates found in the area are sambar (*Cervus unicolor*), chital (*Axis axis*), hog deer (*Axis porcinus*), Barking deer (*Muntiacus muntjac*), Wild boar (*Sus scrofa*). Among big cats Tiger (*Panthera tigris*) and Leopard (*Panthera pardus*) are found in the area. There are a 16 spp. of turtles and 30 spp. of fishes found in river systems of J.W.L.S.

## Chapter 4

### METHODS

**Study period :** This study was conducted from December 1998 to April 1999 at JWLS.

The following are the field and analytical methods adopted for the study.

#### 4.1 Introduction

The Neu *et al.* (1974) analysis on availability - utilization is based on the accurate proportions of each and every habitat parameters available (mapping technique) (Alldredge and Ratti 1992). Vegetation and terrain maps, or aerial photographs are used to determine availability (e.g., Neu *et al.* 1974, Hirst 1975, Irwin 1975, Peek *et al.* 1976 in Marcum Loftsgarden 1980, Risenhoover and Bailey 1985). Marcum Loftsgarden (1980) suggested a non-mapping technique which involves random sampling of the habitat based on a dot grid. This technique has been applied to determine the availability for Big horn Sheep (Dodd & smith 1988). Other workers divided the area into grids and quantified each grid for habitat availability. (Ben Shahr 1990).

My objective for quantification of habitat was to obtain a quantitative description of habitat and availability of the different vegetation types or habitat types, and to determine the availability of assorted habitat components. I followed a modified version of the Marcum Loftsgarden (1980) technique. Though he has recommended the use of this technique in rugged mountains, still I used it because it circumvents the problems faced in mapping areas for vegetation and allows the simultaneous determination of availability of other habitat components.

Due to non availability of a relatively small scaled map, I couldn't sample the habitat based on randomly distributed points on the map as suggested by Marcum Loftsgarden (1980). Therefore I sampled the habitat along my line transects which were laid randomly in each habitat types. Riney (1982) has suggested a similar technique of

habitat sampling along transects which are used for monitoring. Data were collected on the following major aspects:

1. Habitat availability
2. Availability of habitat variables
3. Utilization of habitat and its variable.
4. Degradation of habitat
5. Disturbance

#### **4.2 Selection of intensive study area and habitat stratification:**

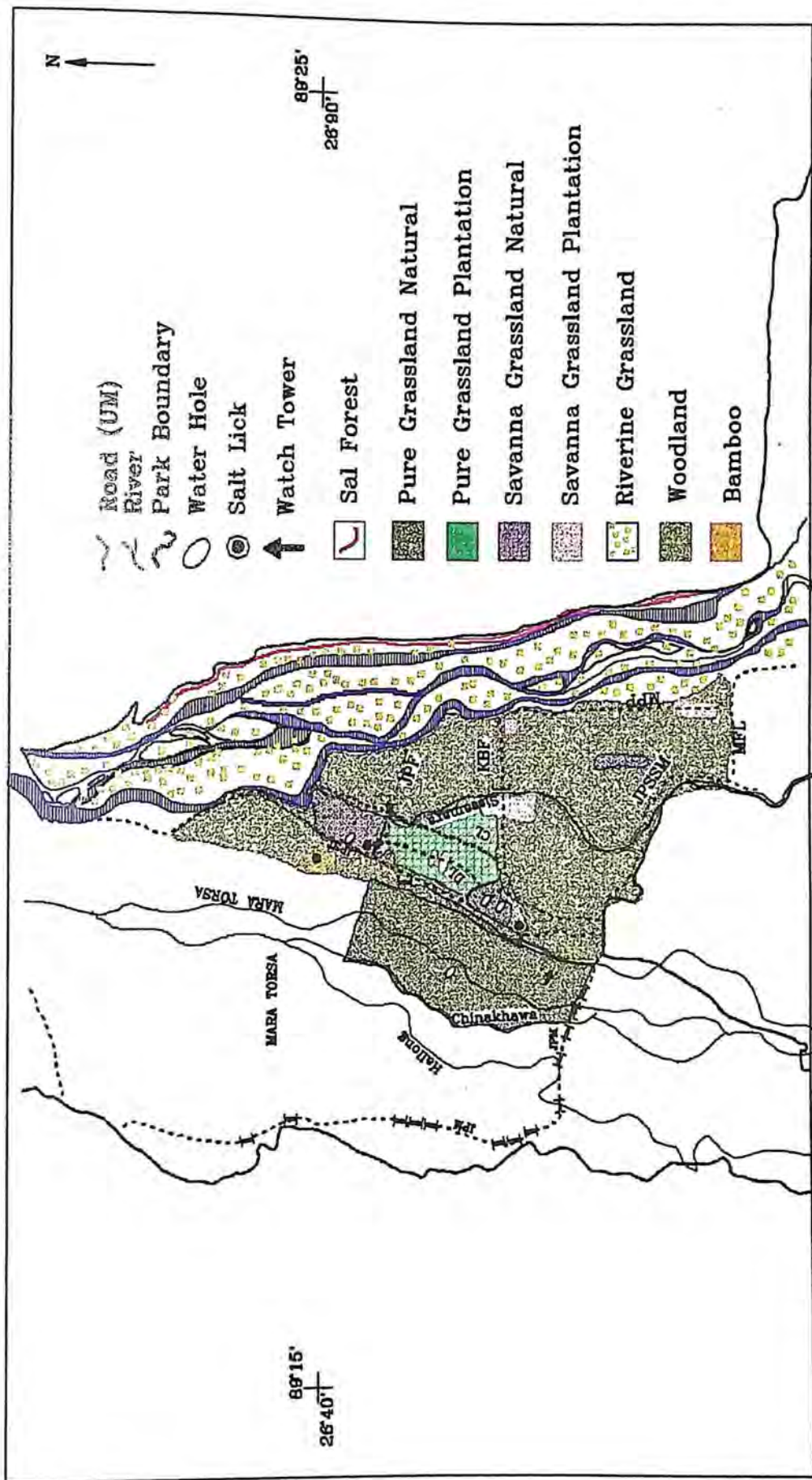
The initial 15 days during the study period were spent in surveying the study area and in identifying areas used by hog deer, and to relate these areas to the broad vegetation categories as mentioned by the previous studies done in this area. As already mentioned, from literature review and also from my initial survey this study was restricted to the different types of grasslands pertaining to their use by hog deer. Hence an attempt was made to identify the different types of grasslands as classified by Pandit (1996).

1. Grasslands
2. Grasslands with khair sisso succession, and
3. Grasslands with simlirish succession.

However in the present study it was not possible to demarcate and visually differentiate between the above grassland types. Hence the following stratification of grassland was adopted (Plate 4.1) :

1. ***Pure grasslands*** (Natural and Plantation)
2. ***Savanna grasslands*** (Natural and Plantation).
3. ***Riverine grasslands***.

This stratification is applicable only to my intensive study area which includes Jaldapara, Malangi and Harindanga (Compartments JP5, JP3, M1, M2 and M3). Among the different habitat types. Riverine grassland were most heterogeneous in composition and Savanna and Pure grassland most homogenous. Pure grassland (natural) were the



Vegetation Map of Intensive Study Area in Jaldapara Wildlife Sanctuary (1999)

Plate 4.1

patches with natural stretches of areas dominated mainly by grasses and very few woody species. These areas were not treated under any plantation operation so far. Pure grassland (Plantation) had pure patches of forage species for rhino *Saccharum arundinaceum*. Savanna grassland (natural) and pure grassland (natural) were very similar in their grass composition but varied in their cover and also woody species. On the other hand Savanna grassland (plantation) was mostly patches of *Saccharum arundinaceum* with different woody species. Riverine grassland on the other hand had two distinct communities which could be identified visually, pure strands of *Vetiveria zizinooides* about 2-3 mt. tall and grasslands with *Dalbergia sissoo* (sissoo), *Bombax ceiba* (simul) and *Acacia catechu* (khair) respectively. JWLS maintains a record of plantations in a meticulous way and compartment boundaries are well demarcated. So it was also possible to get an area for each habitat type identified during this study. Information on these habitat types is given in Table 4.1.

Table 4.1 Description of habitat types in intensive study area.

Habitat type	Area (ha)	Study area	comp	Remark
Pure grassland (natural) (PGLN)	150	Harindanga	Jp5	This is the only stretch of pure natural grassland within the sanctuary. This was the older course of Torsa way back in 1960. Maintained mostly by annual flooding, fire, cut break or over wood removal.
Pure grassland (plantation) (PGLP)	80	Jaldapara Malangi	Jp3 M1 Jp5	They form the most homogenous and dominant patches of grassland within the sanctuary. Plantation of fodder species is done for sustainable management of rhinos. They are also maintained by cut break, over wood and fire. Annual flooding of these areas varies.
Savanna grassland (natural) (SGLN)	84	Jaldapara Malangi	Jp3 M1	Though Jaldapara was once known for its natural stretches of savanna grassland, at present it hardly exists. Within my intensive study area a total of 80 ha is in this category. But out of this only 35 ha was included within the study since the rest 40 ha was found within a dense patch of forest after the lapse of one field working season.
Savanna grassland (Plantation) (SGLP)	133	Jaldapara Malangi	Jp3 M1 M2	Most of the plantations done after cut break or over wood removal has ultimately resulted into this habitat category. Though this area happened to be a pure grassland originally, at present it is mostly invaded by woody species and different weeds and hence moving towards a higher successional stage. The forest department is trying its best to revert these areas back to grassland by carrying out fodder plantations in such areas. Hence most of the plantations in woodland area have resulted into this habitat category, some of them are completely lost due to weed invasion. At present a total of 79.5 ha of plantations are completely lost due to weed invasion, mainly <i>Clerodendron</i> sp., <i>Mikania</i> sp, and fern.
Riverine grassland (RGL)	160	Malangi, Jaldapara	Jp3. M3	Purely natural in origin and characterized by patches of grassland along the river bed. These grasslands are most prone to stochastic changes. Each year there is some change in the overall availability of grasslands within this habitat category since either it gets washed off completely or is converted into pure stretches of sand bed. Thus riverine grasslands are in their seral stage of succession because of annual flooding and erosion.

A comparative map (Plate 4.2) of how the overall area of these different habitat types have changed since past years is included in the thesis to give an idea of how we are losing the natural stretches of grassland either due to stochastic or artificial forces. Abbreviated forms of habitat types mentioned above in table 4.1 are used in the text in later chapters.

#### 4.3 Laying of transects

Once the stratification of different habitat type was done, transects were laid randomly so that all the vegetation types within each habitat types are sampled. In all 9 transects were laid ranging from (0.7- 2.2 km) and used to bisect only one habitat type, excepting two transects which fell in two habitat types others fell in just one habitat type. All the transects were marked at every 100m and their habitat type was noted. Plate 4.3 shows the location of transects in study area.

**Table 4.2. Details of areas of habitat sampled.**

Habitat type (Km <sup>2</sup> )	Proportional Area(T=5 Km <sup>2</sup> )	Transect length (Km)	Total length (T=11.9 Km)	Proportional TL/HBT
Pgln (1.50)	0.248	1.6, 2.1	3.8	0.31
Pglp (0.80)	0.132	1.4,0.7	2.1	0.17
Sgln (0.84)	0.098	0.9	0.9	0.07
Sglp (1.33)	0.215	0.9, 1.00	1.9	0.15
Rgl (1.60)	0.265	1.4,1.3,1.5	3.2	0.26

All the transects were marked at every 100m, to divide them into segments. Sampling was done within each of these segments and data pertaining to objectives stated was collected.

#### 4.4 Habitat Availability

Quantification of availability was done for both the seasons (summer and winter) along these transects. However, in case of SGLN sampling for availability could not be done for the 10 ha patch in winter due to its unexpected burning in early winter. Rest 25 ha is the main rhino use zone hence was not logistically possible to traverse it on foot. For this area sampling was done from a nature trail in both the seasons.

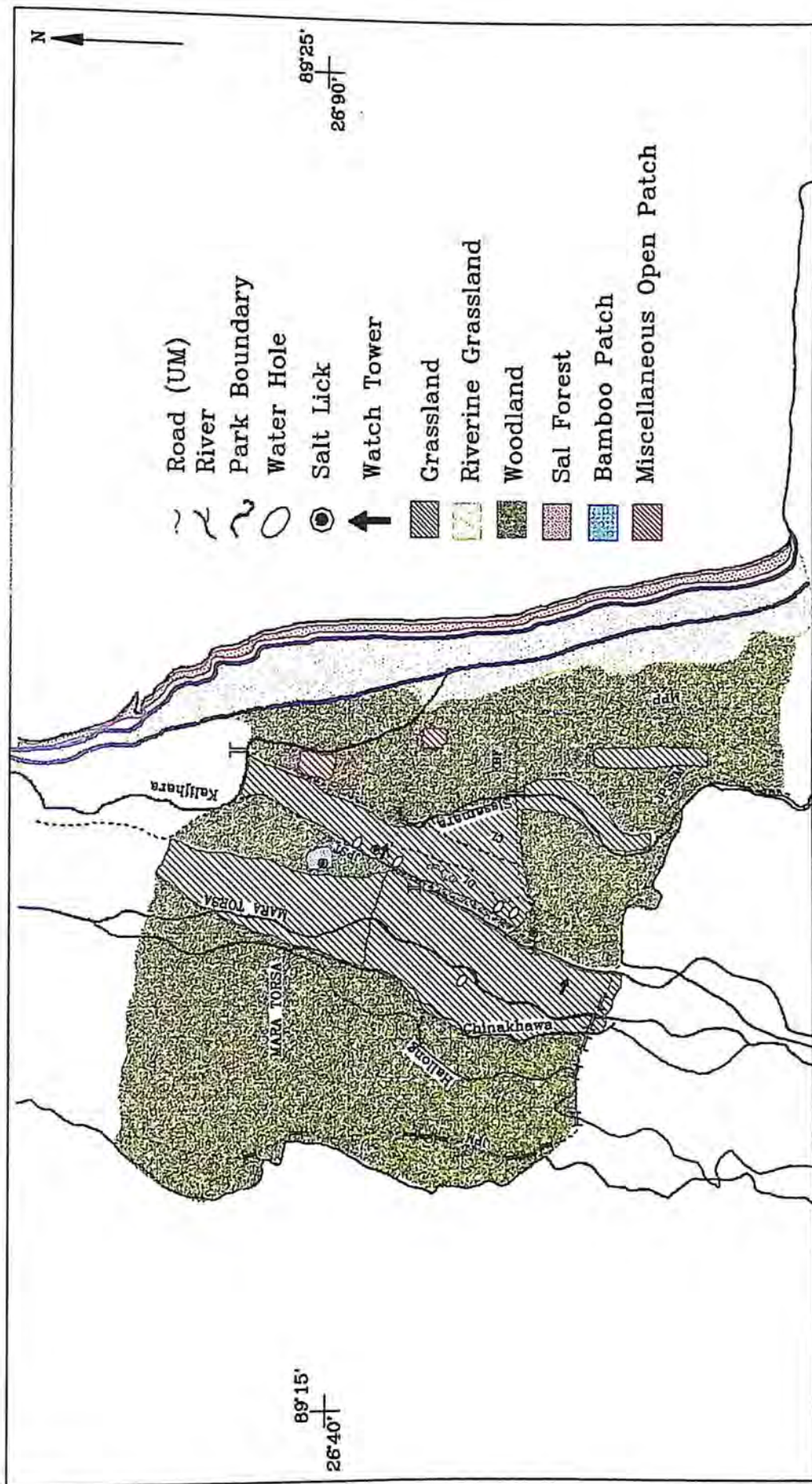


Plate No. 4.2 Vegetation Map of Jaldapara Wildlife Sancturay, 1989

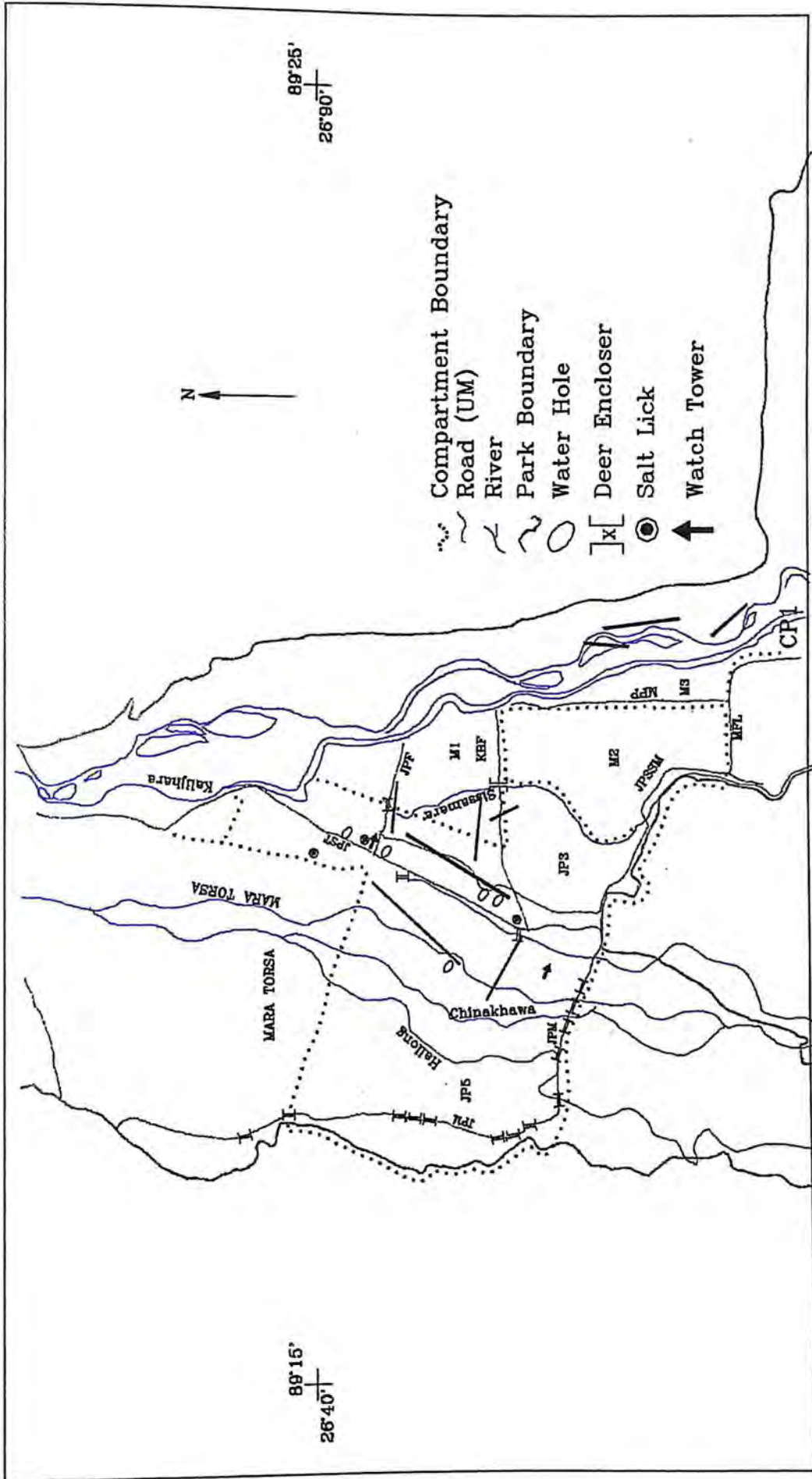


Plate No.4.3 : Map of Intensive Study Area with location of Transects

Since habitat use by any species is governed by the availability of food, cover and water, so it was presumed that these habitat variables could play a significant role in selection of a habitat type by the hog deer.

#### 4.4.1 Forage

Hog deer being an obligate species of grassland, grasses are presumed to form their major forage. Hence availability of different grass species was quantified in both the season by the Quadrat method using Braun-Blanquet scale. This scale was modified slightly and was converted to 5 scales from 7 for my own convenience. This scale was consistently used all throughout the study for forage and cover estimation. ( 0=0%, 1=1-25%, 2=26-50%, 3=51-75%, and 4= >76%)

At every 100 m three 2mX2m Quadrat plots were laid , one on the transect and two, 5m on either sides of the transect. Within each plot following information on forage was collected:

--**Grass height** : was measured at 4 corners and centre of the plot to give an idea about the average ht. and growth stage of the available forage.

--**Phenophase** : of grasses within the quadrat was noted according to Braun-Blanquet scale with slight variation. I used the above 5 scales to quantify the % of Fresh Sprouts (FS), Young shoots (YS), Matured (M), Dead (D), Flowering (Flr) and Fruiting (Fr) phenophase of grasses within each plot. In analysis information on FS, YS and M were only used.

--**Grass species**: within each plot was ranked according to their % ocular cover using the above scale.

Later on information on grass height was also used to check for differences in visibility across different habitat types.

#### 4.4.2 Cover

Quantification of cover was enumerated both by measuring average grass height and obstruction of vision by checker board method. Here cover strictly means escape cover the animal selects when disturbed.

--- *Cover from average grass height*: Average grass height was pooled into four classes namely Class I (1-50cm), Class II (51-100cm), Class III (101-200) and Class IV (>200cm). These cover classes were decided keeping in view the morphology of hog deer.

--- *Checkered board method* : Checkered board method was slightly modified. A pole marked at an interval of 50 cm was used to collect information of obstruction of vision at different heights by placing it 5 meters away from the observer on either side of the transect. At 50, 100 and 150 m above the ground, visibility was quantified in term of 1 (1= obstruction of vision) or 0 ( 0 = no obstruction at all). Cover here means escape cover which an animal uses to take shelter from predators or any other disturbance.

#### 4.5 Habitat Utilization

Data on habitat use by ungulates have been gathered by obtaining periodic locations of radio-collared or marked animals (E.g. Fiesta-Branchet 1988, Krausman & Leopold 1986, Foxet al. 1989). Some studies involved regular monitoring of fixed routes, or transects in order to obtain animal locations (e.g. Gordan 1989a, Ben-Shahar 1990, Pratt et al. 1986). To obtain information on habitat use both direct and indirect sampling, I followed:

##### 4.5.1 Direct sampling

Initially for getting animal location I used the line transect method. But later it was dropped since visibility was very low because of high cover, also logistically it was difficult to walk within pure grasslands. Hence the use of transects to quantify habitat

use by hog deer was discontinued, instead elephants were used to traverse each habitat type and get an encounter rate (ER=Total individuals sighted /day). Later ER were used to create an abundance index for each habitat type in terms of abundance /hr.

Abundance index = ER / Total time spent \* 60

Mostly trails were started 30 min before sunrise but time couldn't be maintained consistently since I had to depend on patrolling staff for my work. Once an individual or group of individual was sighted the following habitat attributes were recorded according to their order of dominance in that area. Later data was transferred to their respective data sheets:

--*Grass phenology* (1= Fresh Sprouts, 2=Young Shoots, 3=Matured)

--*Dominant grass species*

--*Cover or Escape cover* (1=1- 50 cm, 2=51- 100 cm, 3=101-200 cm, 4=> 200 cm)

--*Burnt or Unburnt* ( 1= B, 2= UB)

Since only dominant habitat variables were recorded to provide a clue on its habitat utilization so while comparing availability with utilization by Neu *et al* (1974) data on availability of habitat attributes was slightly modified. Information on availability of habitat attributes were collected in 5 scales (0= 0%, 1= 1-25%, 2= 26-50%, 3= 51-75% and 4= >76%) but during utilization only habitat attribute variable which had > 50% contribution in an area was recorded. So from availability data variables having % O.C. more than 50% (i.e. scale 3 and 4) was pooled while quantifying preference for habitat attributes.

During analysis information on grass species was dropped. To check for the differences in visibility in each habitat type average grass height was compared between seasons and different habitat types. Results are discussed in section 5.2.1

#### 4.5.2 Indirect sampling

Indirect evidences such as dung or pellet group count technique has long been used in wildlife studies for a variety of purpose (Putman 1984). However, its use for finding out the habitat occupancy of ungulates is debatable. While Collins (1981) and Collins & Urnes (1984) questioned the validity of this technique as data did not support the basic assumptions i.e., rate of fecal deposition as a linear function of time and equal average defecation rates between adjacent habitats. Lofts & Kie (1988) and Dineal Edge & Les Marcum (1989) found that the technique provide reliable estimates of habitat use for ungulates. It has been used extensively for quantifying habitat use, Ungulate–Habitat relationship in the Indian subcontinent (Eisenberg and Lockhart 1972, Berwick 1974, Dinerstein 1979, Khan 1993, Sankar 1994). In this study also pellet group counts were done in belt transects in addition to direct sighting to quantify habitat use by hog deer. Dung counts were done in each segment of the transects within a distance of 1m on either side (100 m X 2m). All the transects in each habitat types were monitored every month at a fixed interval. Pellets groups were counted in each segment and then removed. Differentiation of pellets between the ungulates were done very easily. Sambar and chital pellets were larger than those of hog deer whereas barking deer pellets were smaller than hog deer. Wild boar pellets were very distinct from others by their conical shape, color, and size. In some cases pellets of hog deer were confused with chital but when broken by hand could be easily distinguished from chital pellet since they contained coarse browse material, whereas hog deer pellets were smooth and did not contain browsed material (Dhungel and Gara 1991). All those cases where there was some confusion regarding the identification of pellets were not included during sampling. All the line transects were monitored every month.

I didn't quantify the predicting variables for rhino, chital and cattle since they are generalist i.e., subsisting on a mixed diet of grass and browse and adapted to a

variety of topography and vegetation types. So it is highly unlikely that their distribution will be strongly influenced by few habitat variables as may be the case with hog deer which inhabits terai grasslands only. Pellet group counts or dung density were used only to give an idea about the relative occupancy of different habitat types by hog deer, rhino, chital and cattle. Comparison of dung density between species cannot be done because of the difference in defecation rates between them (Dhungel 1985, Dinerstein & Dublin 1982). Such a comparison is not possible with rhino since their ecology and physiology is remarkably different from hog deer, chital and cattle. Thus direct method is the only way to get an idea about the relative use of different habitat types by rhino in relation to hog deer and chital. Whereas dung count is the only way to compare the use of different habitat type by cattle since they were never found to enter the park before 10.00 AM. However the results of pellet group counts can be used to compare the habitat use between hog deer and chital since they are congeneric.

#### **4.6 Degradation of grasslands**

Most of the grasslands of Jaldapara exhibit a variety of weeds and climbers. Hence presence and abundance of weeds was used as an indicator of degraded habitat. Also grasslands of Jaldapara are in a seral stage of succession so woody species were quantified to provide an idea about the status of these habitats in terms of weed and woodland invasion.

##### **4.6.1 Quantification of weeds:**

---Among the weeds present in the sanctuary *Mikania* and Fern were the most dominating species intruding any habitat type. Since these two species couldn't be quantified numerically hence the Braun -Blanquet scale was used to quantify % ocular cover of these species in 2X2m quadrat at every 100 m.

---5 m circular plots were used to quantify rest of the weed species. At every 100 m one 5m circular plot was laid and total enumeration of different species was done to calculate weed density per hectare for each habitat type.

#### 4.6.2 Woodland encroachment:

To quantify woodland encroachment 10m circular plots were laid on the transects at every 100m and all woody species were counted to calculate density per hectare for each GBH class. All woody species encountered were classified into matured tree (> 20 cm GBH), pole stage (11-20 cm GBH), recruitment class (5-10 cm GBH), sapling (1-5 cm GBH) and seedling (< 1 cm GBH) according to their GBH.

#### 4.7 Disturbance

Disturbance in each habitat type was quantified while quantifying availability. Grasslands of Jaldapara are always under the pressure of cutting because of annual harvest of thatch grass (*Imperata cylindrica*) by the local people and grazing by livestock and camp elephants. Hence cut grass, occurrence of fire were used as indicators of disturbance. Cut grass could be very easily differentiated from grazed grasses by checking for even cut marks. Grasses having cut signs at an even ht. and smooth edge was a sign of cut. Whereas if grazed the cut edge was found to be rough. Information on cutting and grazing was quantified by the same method used for habitat availability using similar scales in each 2mX2m quadrat at every 100m. For fire it was just seen whether the plot was burnt or not.

#### 4.8 Analysis of data

For analysis of habitat use data, techniques vary from simple habitat use indices (E.g., Pratt *et al* 1986, Gordon 1989a, Escos and Alados 1992) to multivariate technique's (Krauseman and Leopold 1986, Dodd and smith 1988). Multiple regression, regression analysis and correspondence analysis have also been used (e.g., Nievergelt 1981, Irby 1982, Ben Shahr 1990).

I used the technique suggested by Neu *et al.* (1974) because it is less sensitive to individual variation in both use and availability estimates, which appears to be associated with greater consistency of results (McClellan *et al* 1999) It involves the use of Bonferroni z statistics in conjugation with chi-square. Chi-square tests the hypothesis

that the animal uses habitat categories in proportion to their availability. Bonferroni z statistics determines the observations in the data that contribute most to the calculated chi-square value, and thereby evaluates whether a habitat category is preferred, avoided or used in proportion to availability. The significance level was set at  $p \leq 0.05$ . For Neu *et al* analysis all the sightings whether in group or solitary individual were treated as one and compared with availability.

In addition to this data was subjected to KS tests to check for the normality distribution. The null hypothesis of having a normal distribution was rejected and non-parametric tests were used. Kruskal Wallis non parametric tests were used to check for significant differences between habitat use of hog deer and other sympatric species. In addition to that chi-square tests were used to compare differences in pellet group densities between cut and un-cut areas. The significance level was set at  $p \leq 0.05$ .

Categories of habitat parameters were merged if the number the sighting in that category were low for statistical analysis (Siegel 1956).

For identifying different grassland communities in each habitat types a TWINSpan (Hill 1979) analysis was done to identify different communities in each habitat type and hence differentiate between different habitat types.

## Chapter 5

### Results

#### 5.1 Vegetation Community and Habitat Classification

To identify vegetation communities in each habitat types stratified during the field study TWINSpan (Hill 1979) analysis was used. Data for identification of vegetation communities was taken from the plots laid to collect information about the availability of forage. In all 396 plots (2m X 2m ) were laid but only 394 plots were used for the analysis.

Results of TWINSpan analysis is shown by a simple unscaled dendrogram (Forbes 1994) of the vegetation associations along with the eigen values ( I ) (Fig 5). TWINSpan analysis at the first level broadly identified two major communities of *Vetiveria zizinooides* - *Imperata cylindrica* ( 312 plots) and *Imperata cylindrica* (82 plots). In all at the end ( 5<sup>th</sup> level of division ) 11 different communities were identified. Some of the vegetation associations which could explain the habitat types could be identified at 3<sup>rd</sup> and 4<sup>th</sup> level of division only ( RGL, PGLN, SGLN, SGLP) but for identification of community in PGLP analysis had to be done till 5<sup>th</sup> level of division. Community 1 and 3 formed RGL ; 4, 6 and 7 formed SGLP ; 2, 8 and 9 formed PGLN ; 1 and 11 formed SGLN and 5 formed PGLP ( Fig 5 ). *Vetiveria*, *Imperata*, *Typha* and *Mikania* acted as good differential species for identifying each habitat types. For example *Mikania* dominated communities could be easily included under SGLP since this habitat type had vast areas of vegetation under the cover of *Mikania*. On the other hand *Vetiveria* associated communities formed RGL since this species forms the climax grassland community in riverine habitats or fresh sand beds. *Imperata* and *Cymbopogon* communities indicated natural grasslands since these communities were found to exist only in this habitat type in extensive stretches. Table 5 shows the communities identified within each habitat type in terms of their dominance. Results for each habitat types are arranged in terms of their homogeneity. Results show that:

**PGLP** is the most homogenous habitat type with only one vegetation association identified at 5<sup>th</sup> level of division (n= 72). *Saccharum arundinaceum* was the most dominant species along with *Imperata cylindrica* - *Vetiveria zizinooides* as co-dominants. *Imperata cylindrica* and other grasses were found to grow under the dense cover of *Saccharum sp.*. *Saccharum arundinaceum* is a planted species at Jaldapara Wildlife Sanctuary.

In **RGL** two major communities were identified out of which *Vetiveria* associated community was found to be dominant and *Typha* associated communities were found to be located in patches on fresh river bed. *Typha* was found to grow in areas closer to water pools. Within the *Vetiveria zizinooides* - *Imperata cylindrica* - *Arundo donax* associated community *Vetiveria zizinooides* was the most dominant species and occurred in dense homogenous strands. The under storey of these communities were found to lack the growth of any other grass species but sapling and seedling of some woody species were encountered within these strands. On the other hand *Imperata cylindrica*, *Arundo donax* along with other co-dominant species were found to occur in patches outside these strands. Thus in RGL these three species were found to have a mosaic distribution pattern. In *Typha spp* - *Vetiveria zizinooides* - *Cyperus niveus* dominated community *Vetiveria spp.* was found mostly in their young phenophase and hence these community were more open thus allowing the growth of other co-dominant species like *Cyperus niveus*, *Arundo donax*, *Mikania scandens*, fern and others.

In **SGLN** also two major communities were identified *Cymbopogon* associates and *Cyperus* associates. *Cymbopogon flexuosus*- *Hyptis spp* - *Imperata cylindrica* community was the dominant one with *Cymbopogon flexuosus* as the dominant species and *Hyptis* (Wild tulsi) and *Imperata cylindrica* as co-dominants. *Chromolina odorata* and *Mikania scandens* are the other major species found in these habitat type. The community classification in these habitat type clearly indicates a high

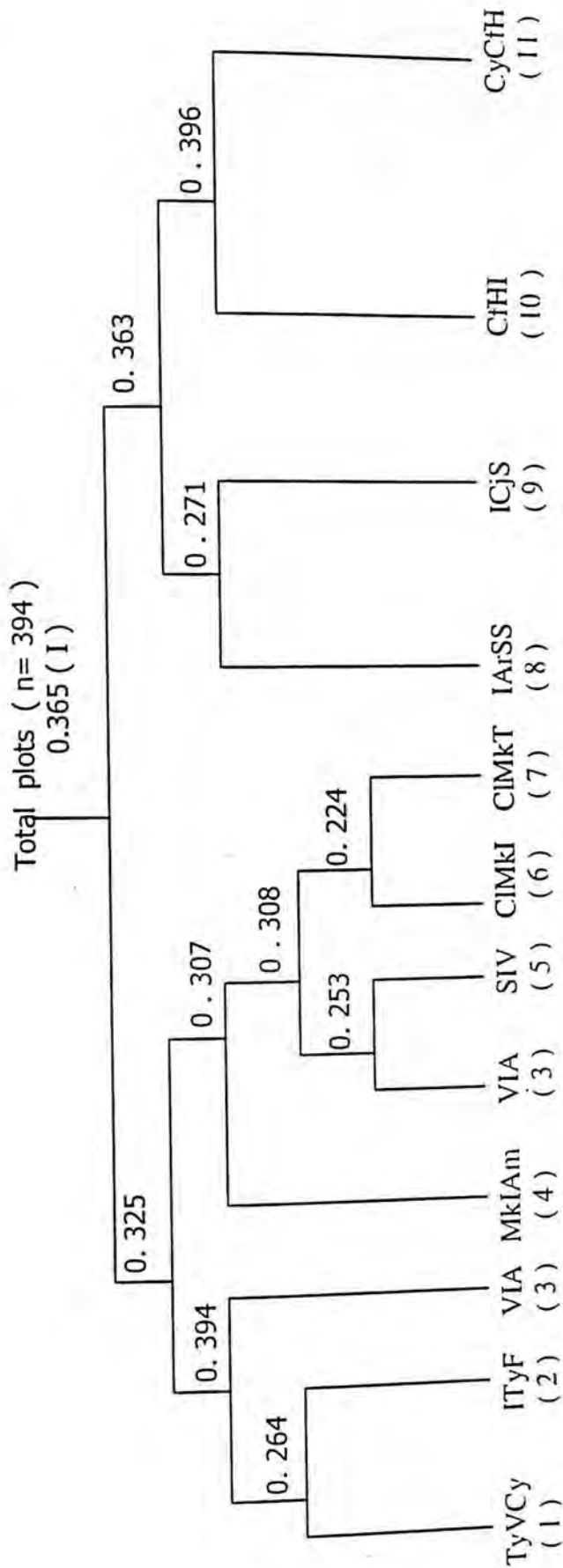
abundance of weeds and lower proportion of foraging species like thatch (*Imperata*). The second community identified includes only 3 plots and fall in area which was earlier a water hole but at present is dry and has no vegetation growth.

Both **PGLN** and **SGLP** showed three major communities. But PGLN was more heterogeneous compared to SGLP because the communities identified had marked differences in their species composition. Whereas the communities of SGLP were relatively less distinct and more homogenous with *Miikania scandens* as dominant in one of the communities. In other two communities *Chromolina odornata* was the dominant and *Mikania* was co-dominant species. The *Mikania* dominated community was also found to have *Imperata cylindrica* and *Apluda mutica* as co-dominant species. *Saccharum arundinaceum*, *Cherodendron viscosum*, *Arundo donax*, *Ageratum conisoides* are the other important species occurring within these communities.

In **PGLN** *Imperata - Arundinella - Sissoo* community was found to be dominant followed by *Imperata - Cymbopogon - Saccharum* and *Imperata - Typha - Fern* association. This habitat type was most heterogeneous with patchy distribution of these communities within the stretch of natural grasslands. *Imperata - Typha - Fern* community was found to be restricted only along the perennial streams and water logged areas within this habitat type. *Dalbergia sissoo* were found to be one of the co-dominant species within this community but they were found to occur only in seedling and sapling stage. Very few matured trees were encountered in this habitat. The 2<sup>nd</sup> community within this habitat also had *Imperata cylindrica* as the dominant species and *Cymbopogon jawarancusa* and *Saccharum spp.* as co-dominants. *Saccharum spp.* was found to occur in patches unlike PGLP where they occurred in homogenous strands.

Table 5 The major communities identified within each habitat types by TWINSpan analysis arranged in order of their dominance from homogenous to heterogenous habitat types within my intensive study area.

Habitat types			
PGLP	<i>Saccharum - Imperata - Vetiveria (n= 72)</i>		
RGL	<i>Vetiveria - Imperata - Arundo (n= 117)</i>	<i>Typha - Vetiveria - Cyperus (n = 10)</i>	
SGLN	<i>Cymbopogon flexuosus - Hyptis - Imperata (n= 15)</i>	<i>Cyperus - C. flexuosus - Hyptis (n = 3)</i>	
SGLP	<i>Mikania - Imperata - Apluda (n= 50)</i>	<i>Chromolina - Mikania - Imperata (n= 36)</i>	<i>Chromolina - Mikania - Tabernamontana (n= 36)</i>
PGLN	<i>Imperata - Arundinella - Sissoo (n = 40)</i>	<i>Imperata - C. jawarancusa - Saccharum (n = 36)</i>	<i>Imperata - Typha - Fern (n = 18)</i>



VEGETAION ASSOCIATIONS

Fig 5 Dendrogram of vegetation classification of JWLS ( I S A ) based on TWINSPLAN ( Hill 1979 ). Numbers above each division are eigen values ( I ).

- 1 Typha spp- Vetiveria zizinooides - Cyperus niveus
- 2 Imperata cylindrica - Typha spp - Fern
- 3 Vetiveria zizinooides - Imperata cylindrica - Arundo donax
- 4 Mikania scandens - Imperata cylindrica - Apluda mutica
- 5 Saccharum arundinaceum - Imperata cylindrica - Vetiveria zizinooides
- 6 Chromolina odornata - Mikania scandens - Imperata cylindrica
- 7 Chromolina odornata - Mikania scandens - Tabernamontana divaricata
- 8 Imperata cylindrica - Arundinella benghalense - Dalbergia sissoo
- 9 Imperata cylindrica - Cymbopogon jawarancusa - Saccharum arundinaceum
- 10 Cymbopogon flexuosus - Hyptis suaveolens - Imperata cylindrica
- 11 Cyperus niveus - Cymbopogon flexuosus - Hyptis suaveolens

## 5.2 Availability of habitat variables

### 5.2.1 Grass height

Since grasslands are the most dynamic structure of the vegetation so there was no need to check for the existence of overall difference in their mean height. Instead the overall variation between seasons and variation of grass height between habitats for each season was compared to check if the variation was significant or not because any significant variation will influence the visibility and induce a bias in the results. Overall mean grass height (cm) was maximum in RGL ( $55.66 \pm 3.40$ ,  $n=252$ ). and minimum in SGLN ( $36.13 \pm 3.10$ ,  $n=72$ ). The variation of mean grass height between season was found to be significant (One way ANOVA  $F = 17.693$ ,  $p=0.000$ ,  $df=1$ ). As there was a significant variation of grass height between winter and summer so utilization of habitat by hog deer was treated for each season separately.

In winter, average grass height was maximum in RGL ( $58.084 \pm 4.61$ ,  $n=126$ ) and minimum in PGLN ( $21.64 \pm 1.75$ ,  $n=111$ ). The overall variation in average grass height in winter was significant ( $p<0.05$ ) (One way ANOVA  $F= 19.046$ ,  $p= 0.000$ ,  $df=4$ ). Mean grass height in RGL was found to be significantly different from PGLN, PGLP, SGLN and SGLP ( $p<0.05$ ) ( $p= 0.000$ ,  $p=0.000$ ,  $p=0.002$  and  $p=0.000$ ) respectively ( Fig. 5.1)

In summer, average grass height was maximum in PGLP ( $56.746 \pm 5.40$ ,  $n=63$ ) and minimum in PGLN ( $40.779 \pm 2.75$ ;  $n= 111$ ). But the overall variation in grass height across habitat types was not significant ( $p>0.05$ ) ( Fig. 5.1).

The overall variation in grass height across different habitat type was significant only in winter in RGL whereas the difference was not significant in summer. So it was assumed that visibility and detectability in other habitat type was constant except for RGL in winter and constant for all other habitat types in summer.

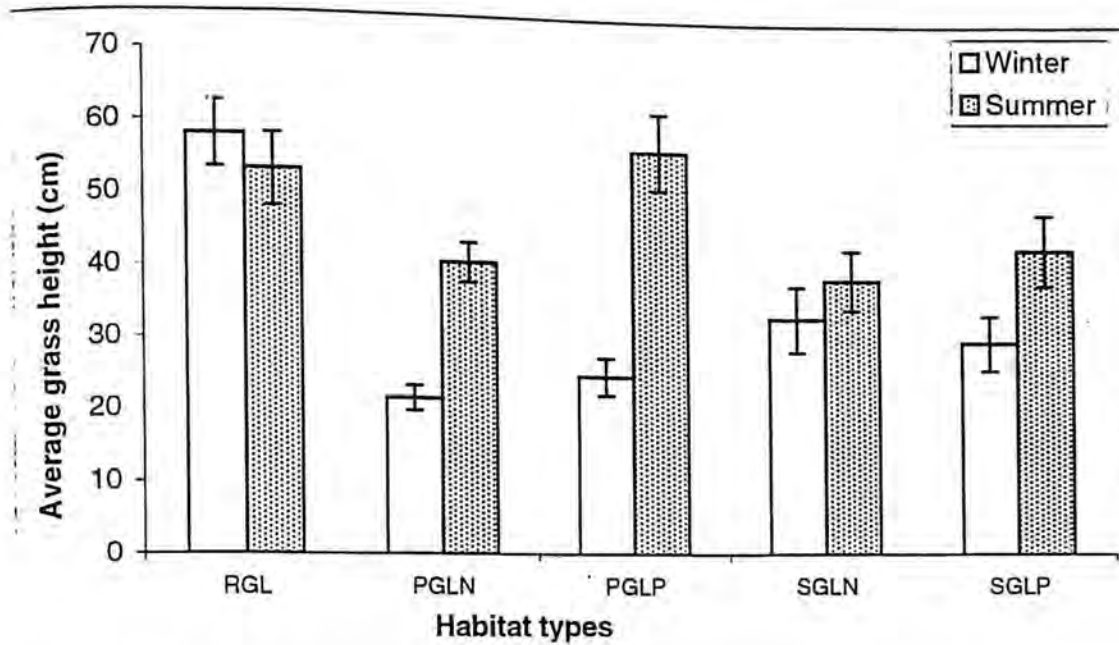


Fig. 5.1 Average available grass height (cm) in different habitat types.

Table 5.1 Percent obstruction of vision in three height classes in winter/summer in different habitat types.

Habitat types	Winter			Summer		
	50 cm	100 cm	150 cm	50 cm	100 cm	150 cm
RGL	96.8	62.6	43.6	95.23	61.11	38
PGLN	99.09	41.4	9	98.19	60.36	34.2
PGLP	100	20.3	6.6	100	80.95	53.9
SGLN	97.2	37.14	8.3	97.2	36.11	11.1
SGLP	100	40	8.2	90	43.3	20

### 5.2.2 Horizontal cover

Proportion of horizontal cover at each class was calculated in terms of percentage occurrence in each class in each habitat for both the seasons (Table 5.1). Higher the obstruction of vision in each habitat type meant the higher presence of cover in that habitat type.

### 5.2.3 Species composition

The proportion of each species for each habitat type was calculated in terms of percentage occurrence in each habitat type. Results are presented for the major species of grasses and weeds which had major influence on hog deer habitat use (Fig 5.2.1 & Fig 5.2.2)

Results on availability of other habitat attributes are included within section 5. 5.

### 5.3 Abundance of species in different habitat types

Overall abundance of hog deer, rhino and chital are compared in different habitat types. Though it was not possible to quantify availability in savanna grassland (natural) in proportion to its availability so I have dropped it from the habitat utilization – availability analysis. But it is included for the overall comparison of abundance /hr .

#### 5.3.1 Hog deer

##### 5.3.1.1 Direct method

In case of hog deer the overall abundance/hr is maximum ( $14.25 \pm 2.02$ ,  $n=32$ ) in Savanna grassland (plantation) and minimum in riverine grassland ( $0.95 \pm 0.06$ ,  $n=118$ ) (Figure 5.3.1). Overall mean abundance of hog deer was significantly different across different habitat types (KW  $\chi^2 = 328.31$ ,  $df=5$ ,  $p=0.000$ ,  $N= 710$ ).

Overall mean abundance/hr in winter was maximum in savanna grassland plantation ( $9.698 \pm 3.42$ ,  $N= 7$ ) and minimum in riverine grassland ( $0.84 \pm .06$ ,  $n=54$ ) (Fig

5.3.2). The overall difference in mean abundance/hr in winter across different habitat types was significant (KW  $\chi^2 = 1.21.16$ ,  $df=5$ ,  $p=0.000$ ,  $n=367$ ).

In summer mean abundance/hr was maximum in Pure grassland (plantation) ( $14.2979 \pm 2.99$ ,  $n= 147$ ) and minimum in Riverine grassland ( $1.0422 \pm 0.10$ ,  $N=64$ ) (Fig.

5.3.2). Overall difference in summer across different habitat types was significant (KW  $\chi^2 = 189.93$ ,  $df=5$ ,  $p=0.000$ ,  $n=349$ ).

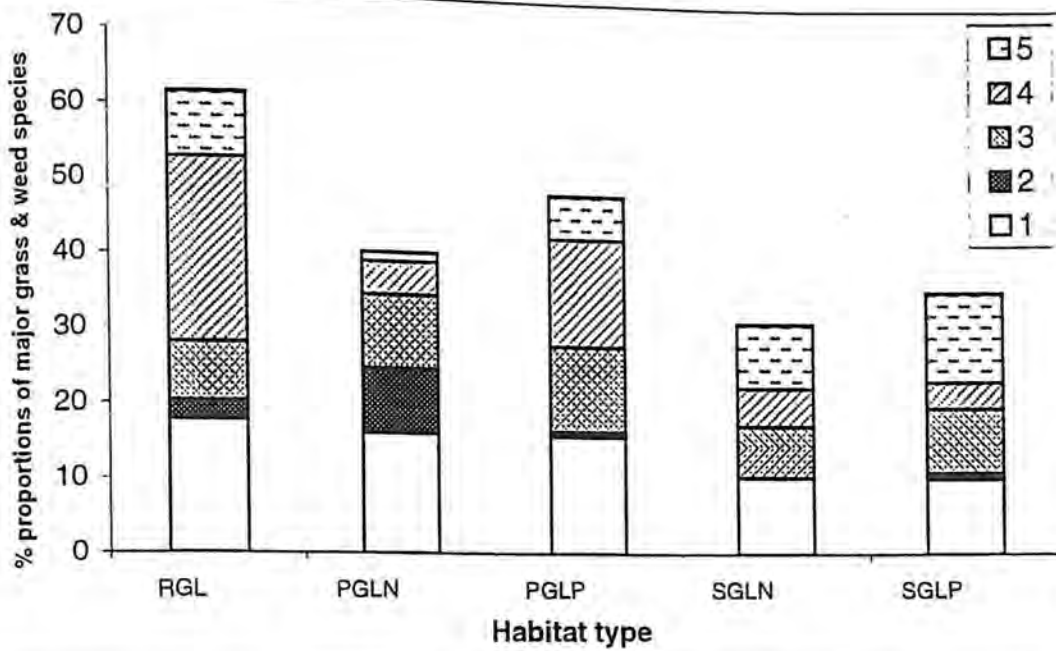


Fig. 5.2.1 Percent Proportion of major grasses and weeds in different habitat types in winter (1= *Imperata cylindrica*, 2= *Cymbopogon flexuosus*, 3= *Saccharum arundinaceum*, 4= *Vetiveria zizinioides* (grasses); 5= *Mikania scandens* (weed)).

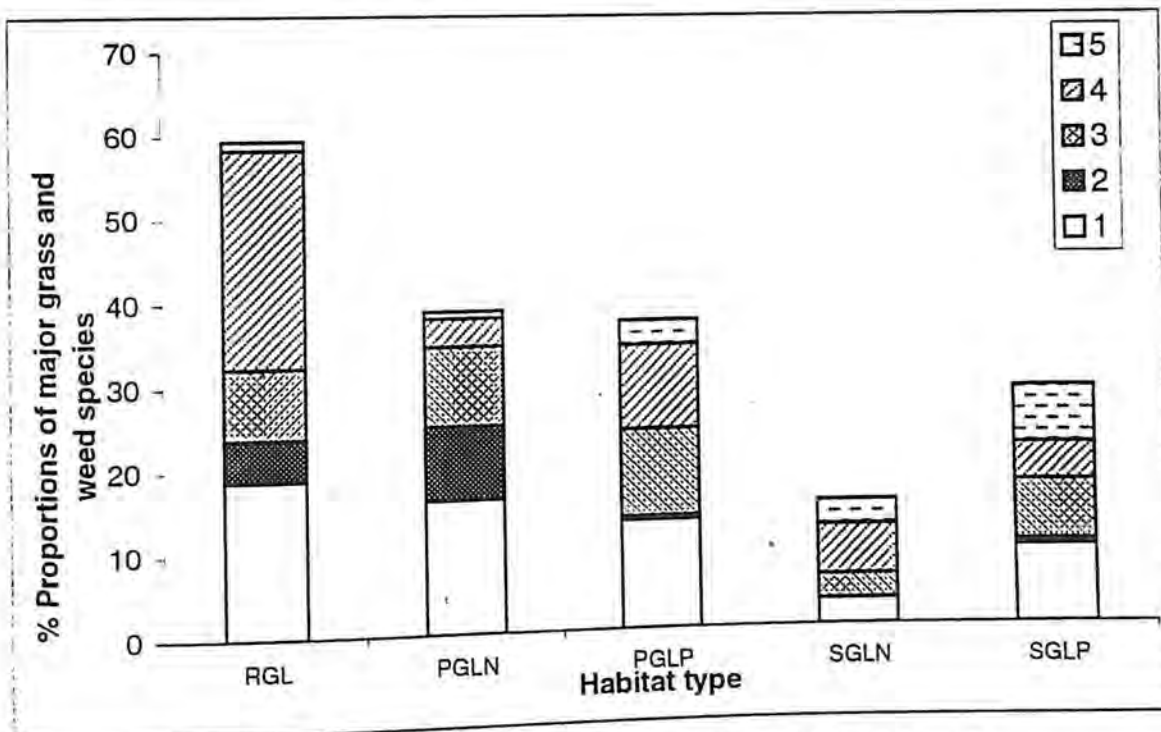


Fig. 5.2.2 Percent Proportion of major grasses and weeds in different habitat types in summer (1= *Imperata cylindrica*, 2= *Cymbopogon flexuosus*, 3= *Saccharum arundinaceum*, 4= *Vetiveria zizinioides* (grasses); 5= *Mikania scandens* (weed)).

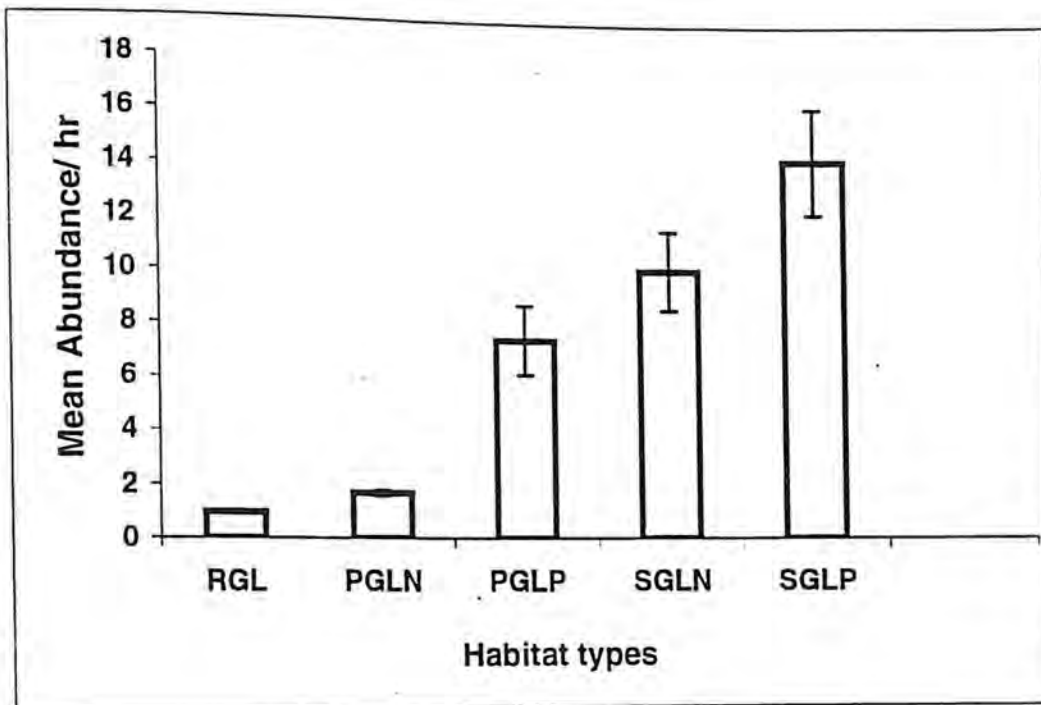


Fig. 5.3.1 Overall Mean Abundance of hog deer in different habitat types

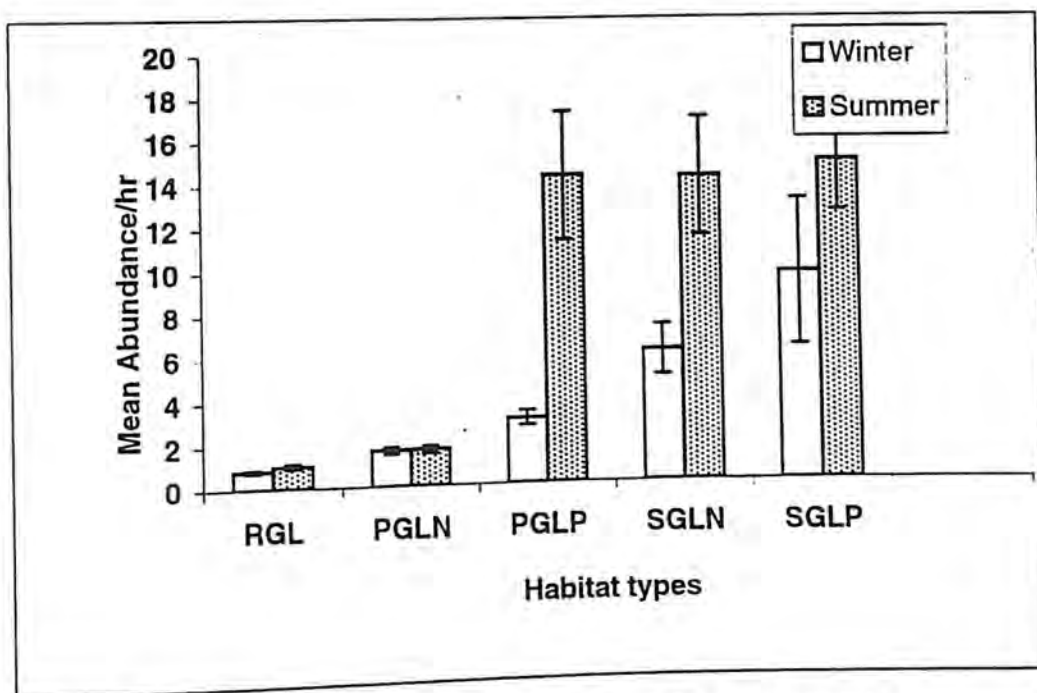


Fig. 5.3.2 Mean Abundance of hog deer in winter and summer in different habitat types

### 5.3.1.2 Pellet group

The overall mean pellet group density/ha of hog deer was maximum in PGLP ( $438.20 \pm 36.32$ ,  $n=106$ ) and minimum in SGLN ( $240.19 \pm 25.82$ ,  $n=51$ ) (Fig. 5.4.1) The variation in overall mean pellet group density/ha in different habitat types was significantly different (KW  $\chi^2 = 17.70$ ,  $df=4$ ,  $p=0.001$ ).

The mean pellet group density/ha in winter was maximum in PGLP ( $387.93 \pm 59.21$ ,  $n=58$ ) and minimum in SGLN ( $244.44 \pm 33.15$ ,  $n=27$ ). (Fig. 5.4.2) Overall variation in pellet group density/ha in different habitat types in winter was not significant ( $p>0.05$ ).

In summer the mean pellet group density/ha was maximum in PGLN ( $574.32 \pm 56.92$ ,  $n=74$ ) and minimum in SGLN ( $235.41 \pm 40.98$ ,  $n=24$ ) (Fig. 5.4.2) Overall variation in pellet group density/ha in different habitat types was significantly different (KW  $\chi^2 = 31.85$ ,  $df=4$ ,  $p=0.000$ ,  $n=264$ ).

### 5.3.2 Chital

#### 5.3.2.1 Direct Observation

The over all abundance of chital was maximum in SGLN ( $3.79 \pm 2.02$ ,  $n=31$ ) and minimum in PGLP ( $0.116 \pm 0.61$ ,  $n=35$ ) (Fig. 5.3.3). However there was no sighting of chital in riverine grassland and pure grassland natural all throughout the study period. Chital sighting in general were very poor compared to hog deer and rhino. The overall variation in mean abundance of chital in different habitat types was significantly different (KW  $\chi^2 = 12.42$ ,  $df=5$ ,  $p=0.02$ ,  $N=131$ ).

In winter overall mean abundance/hr was maximum in SGLN ( $1.51 \pm 0.57$ ,  $n=17$ ) and minimum in PGLP ( $0.03 \pm 0.03$ ,  $n=18$ ) (Fig. 5.3.4). There was no sighting of chital in RGL, PGLN and SGLP. The overall variation was significant across different habitat types (KW  $\chi^2 = 20.902$ ,  $df=5$ ,  $p=0.001$ ,  $N=70$ ).

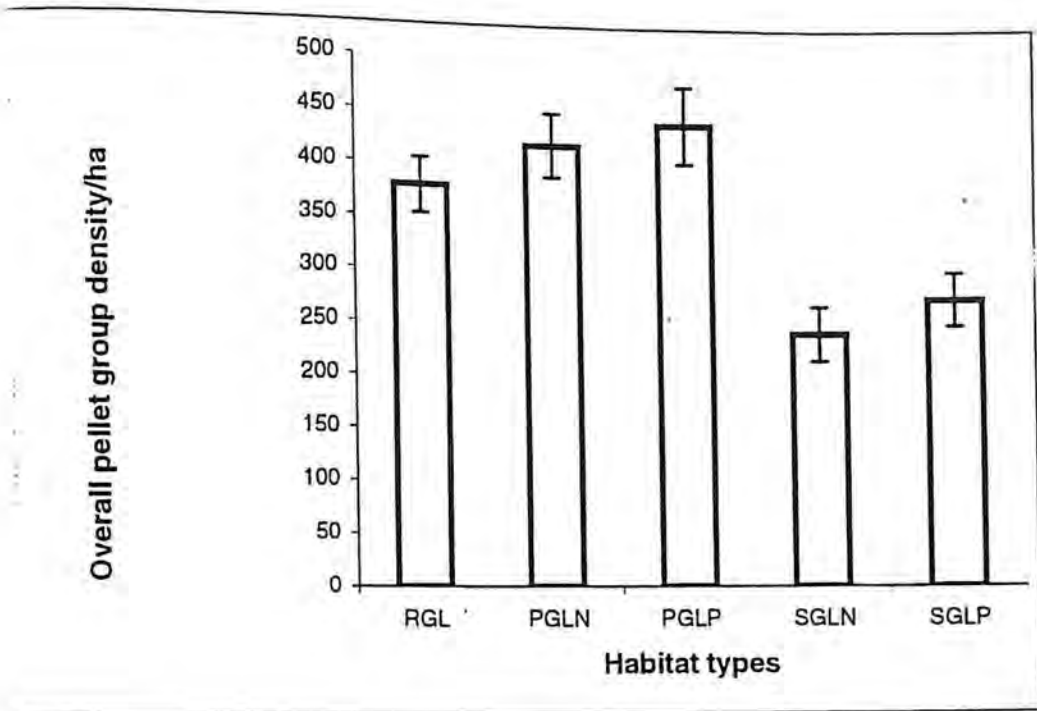


Fig. 5.4.1 Overall pellet group density of hog deer in different habitat types

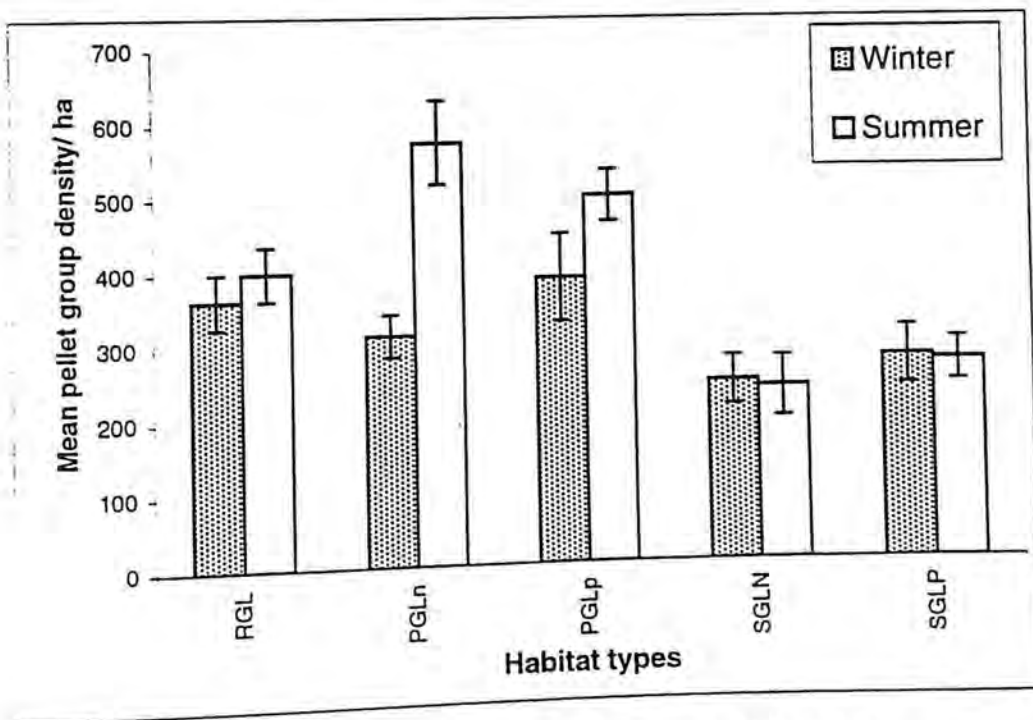


Fig. 5.4.2 Mean pellet group density of hog deer in different habitat types in winter and summer.

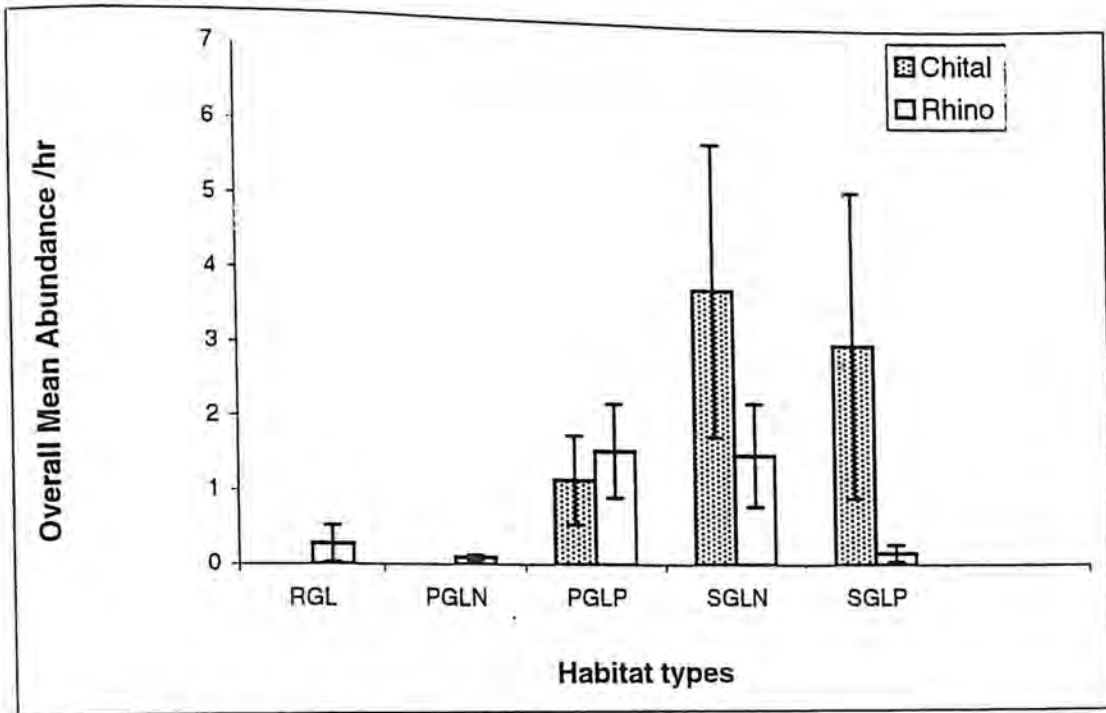


Fig. 5.3.3 Overall mean abundace of chital and rhino in different habitat types

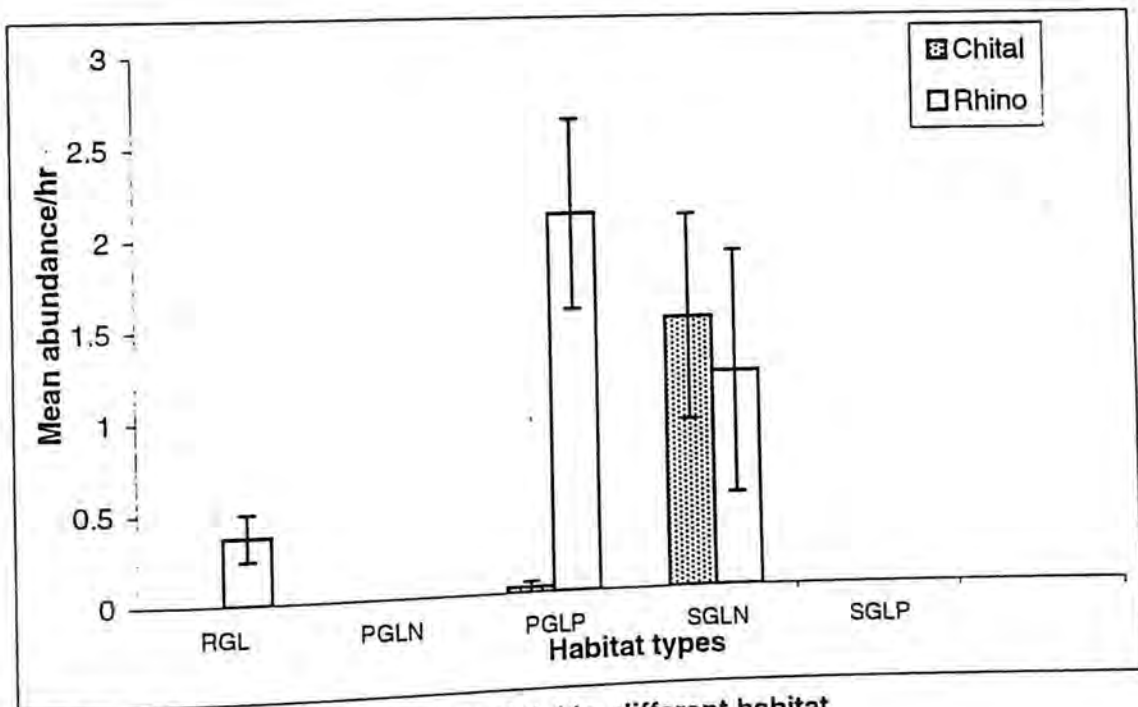


Fig. 5.3.4 Mean Abundance of rhino & chital in different habitat types in winter

In summer mean abundance/hr was maximum in SGLN ( $6.57 \pm 4.40$ ,  $n=14$ ) and minimum in PGLP ( $0.235 \pm 1.21$ ,  $n=17$ ) (Fig. 5.3.5). There were no sighting in RGL and PGLN. The overall variation was not significant ( $p>0.05$ ).

### 5.3.2.2 Pellet Group

The overall mean pellet group density/ha of chital was maximum in SGLN ( $5.88 \pm 3.61$ ,  $n=51$ ) and minimum in PGLN ( $0.54 \pm 0.38$ ,  $n=185$ ) (Fig. 5.4.3). No pellet groups were encountered in RGL. Overall variation in mean pellet group density/ha in different habitat types was significantly different (KW  $\chi^2 = 43.999$ ,  $df=4$ ,  $p=0.001$ ,  $N=614$ ).

In winter pellet groups were encountered only in SGLP and no pellet groups were encountered in RGL, PGLN, PGLP and SGLN . The mean pellet group density/ha in SGLP was ( $11.90 \pm 5.05$ ,  $n=42$ ) and the overall difference was significant across different habitat types (KW  $\chi^2 = 44.636$ ,  $df=4$ ,  $p=0.000$ ,  $N=350$ ) (Fig 5.4.4).

In summer mean pellet group density/ha was maximum in SGLN ( $12.5 \pm 7.52$ ,  $n=24$ ) and minimum in PGLN ( $1.35 \pm 0.94$ ,  $n=74$ ). No pellet groups were encountered in RGL (Fig .5.4.5). The overall variation in mean pellet group density/ha across different habitat types was significant (KW  $\chi^2 = 25.732$ ,  $df=4$ ,  $p=0.000$ ,  $N=264$ ).

### 5.3.3 Rhino

#### 5.3.3.1 Direct Sighting

In case of rhino overall mean abundance/hr was maximum in PGLP ( $1.56 \pm 0.64$ ,  $N=38$ ) and minimum in PGLN ( $0.093 \pm 0.042$ ,  $N=17$ ) (Fig. 5.3.3). The overall variation in mean abundance/hr of rhino in different habitat types was significantly different (KW  $\chi^2 = 41.341$   $df=5$ ,  $p=0.000$ ,  $N=166$ ).

In winter mean abundance/hr was maximum in PGLP ( $2.10 \pm 0.53$ ,  $n=22$ ) and minimum in RGL ( $0.37 \pm 0.13$ ,  $n=9$ ) (Fig. 5.3.4). There were no sightings in PGLN and

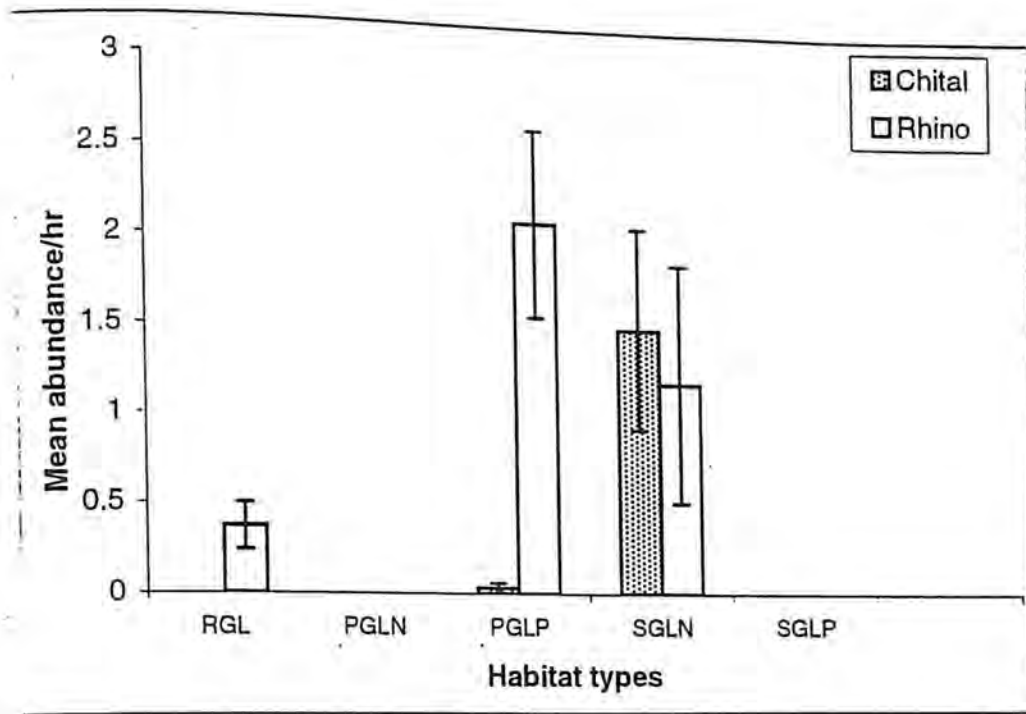


Fig. 5.3.5 Mean Abundance of Chital & Rhino in different habitat types in summer

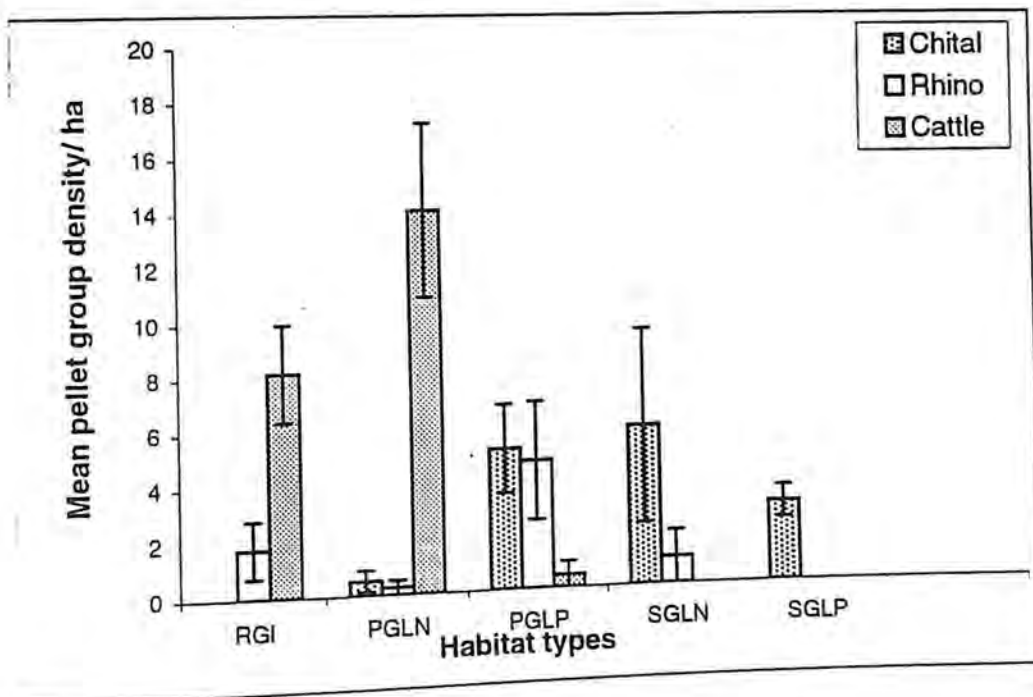


Fig. 5.4.3 Overall mean pellet group density of chital, rhino and cattle in different habitat types.

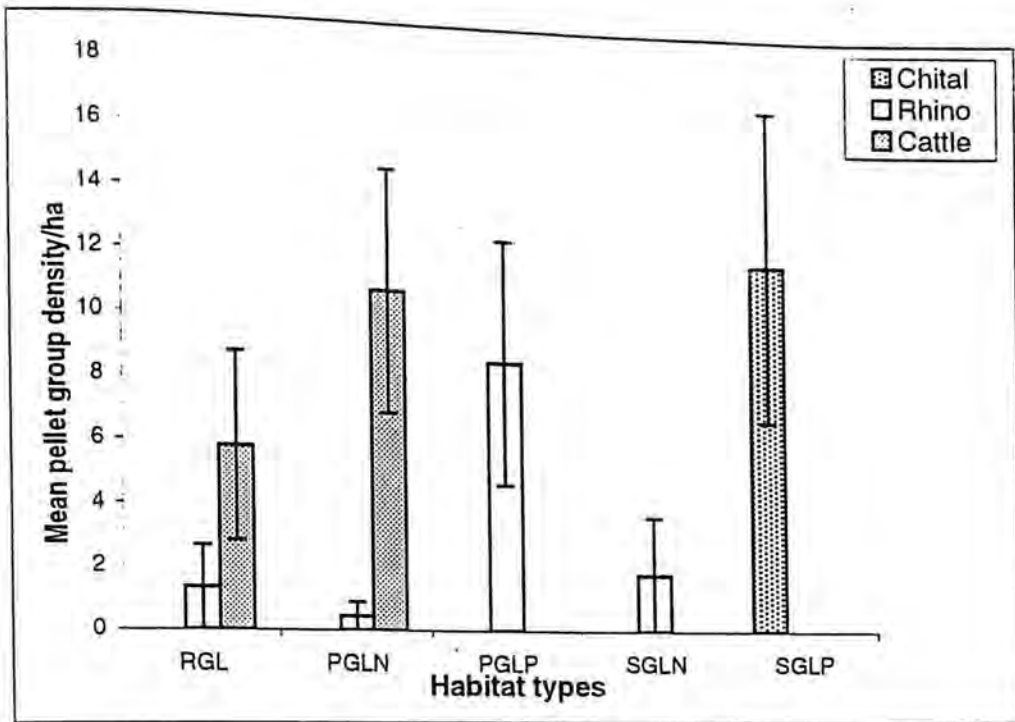


Fig. 5.4.4 Mean pellet group density of chital, rhino and cattle in different habitat types in winter

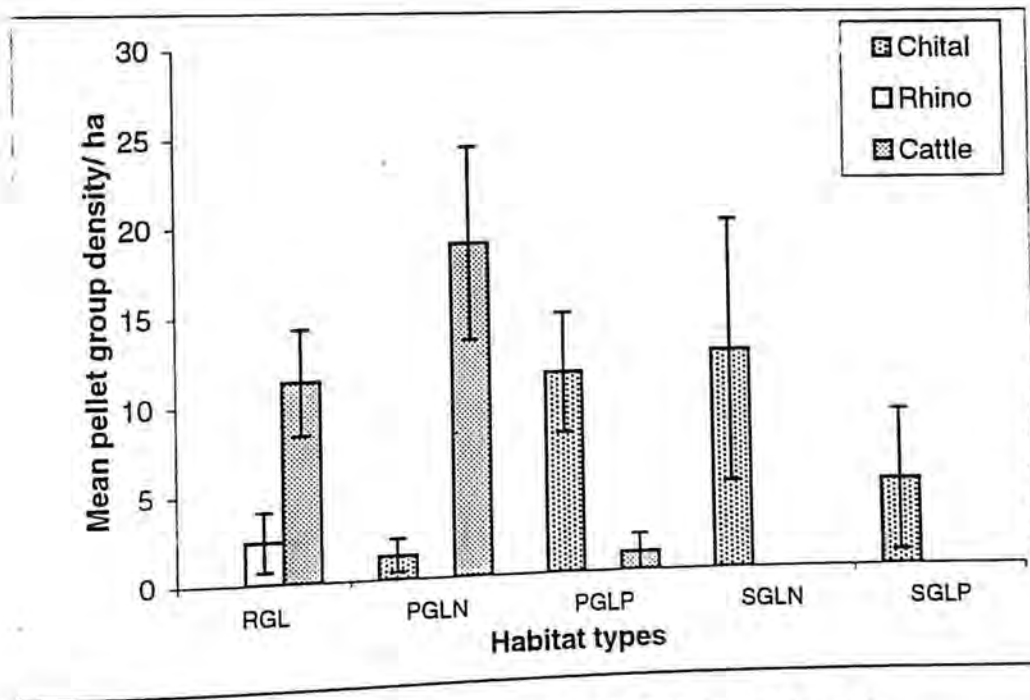


Fig. 5.4.5 Mean pellet group density of chital, rhino and cattle in different habitat types in summer

SGLP. The overall variation in mean abundance/hr in different habitat types was significant (KW  $\chi^2 = 29.365$  df=5, p=0.000, N=95).

In summer mean abundance/hr was maximum in PGLP ( $1.83 \pm 0.75$ , n=16) and minimum in RGL ( $0.17 \pm 0.10$ , n=5) (Fig. 5.3.5). The overall mean abundance/hr across different habitat types was significant (KW  $\chi^2 = 20.053$  df=5, p=0.003, N=71).

### 5.3.3.2 Pellet Group

The mean of overall dung density/ha of rhino was maximum in PGLP ( $4.71 \pm 2.17$ , n=106) and minimum in PGLN ( $0.270 \pm 0.27$ , n=185). No dung was encountered in SGLP. The mean overall dung density/ha was not significant across different habitat types (p > 0.61) (Fig. 5.4.3).

In winter the mean dung density/ha was maximum in PGLP ( $8.620 \pm 3.91$ , n=58) and minimum in PGLN ( $0.450 \pm 0.45$ , n=111) (Fig 5.4.4). No dung was encountered in SGLP. The mean dung density/ha in winter across different habitat types was significant (KW  $\chi^2 = 13.576$ , df = 4, p=0.009, n=350).

In summer dung was encountered only in RGL, mean dung density/ha was ( $2.381 \pm 1.67$ , n= 84) (Fig 5.4.4). Overall variation in mean dung density/ha was not significant across habitat types (p>0.05).

### 5.3.4 Cattle

#### 5.3.4.1 Indirect

Mean overall dung density/ha was maximum in PGLN ( $14.05 \pm 3.19$ , n=185) and minimum in PGLP ( $0.471 \pm 0.47$ , n=106). No cattle dung was encountered in SGLP and SGLN (Fig. 5.4.3). Overall variation in mean dung density in different habitat types was significantly different (KW  $\chi^2 = 28.85$ , df = 4, p=0.000, n=614).

In winter mean cattle dung density/ha was maximum in PGLN ( $10.81 \pm 3.86$ ,  $n=111$ ) and minimum in RGL ( $5.803 \pm 2.97$ ,  $n=112$ ). Cattle dung was not encountered in rest of the habitats (Fig 5.4.4). The overall variation was significant (KW  $\chi^2 = 12.264$ ,  $df = 4$ ,  $p=0.015$ ,  $n=350$ ).

In summer mean cattle dung density was maximum in PGLN ( $18.918 \pm 5.50$ ,  $n=74$ ) and minimum in PGLP ( $1.041 \pm 1.04$ ,  $n=48$ ). No cattle dung was encountered in SGLN and SGLP (Fig. 5.4.5). Overall variation was significant (KW  $\chi^2 = 18.396$ ,  $df = 4$ ,  $p=0.001$ ,  $n=264$ ).

## 5.4 Habitat selection

Data on the overall and seasonal selection of different habitat types was analysed separately for winter and summer for hog deer, spotted deer and rhino. Both direct and indirect methods were used to quantify the selection of habitats types. As stated earlier all the sightings whether of solitary individuals or groups were counted as one. The results of habitat selection are as follows:

### 5.4. 1. Hog deer

#### 5.4.1.1. Direct sighting

On analysing data on overall use of the broad habitat types, it was that hog deer preferred PGLN and SGLN and avoided RGL and SGLP. PGLP was used in proportion to its availability ( $p<0.05$ ) (Table 5.2).

Both in winter and summer it was found that hog deer preferred natural grassland (PGLN) and avoided RGL and SGLP. Plantation grassland (PGLP) and SGLN were used in proportion to their availability ( $p<0.05$ ) (Table 5.3 & 5.4).

#### 5.4.1.2 Indirect sighting

On analysing data on overall habitat use from pellet group counts, it was also observed that none of the habitat types were used in proportion to their availability in all

**Table 5.2 Chi-square value and overall intensity of use of different habitat types by hog deer based on direct sightings ( $\chi^2 = 128.383, Z=2.6399$ )**

Habitat type	No. of groups sighted	Expected proportional Usage	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	118	0.265	0.165	0.254	-
PGLN	290	0.248	0.336	0.442	+
PGLP	91	0.132	0.122	0.202	*
SGLN	103	0.098	0.141	0.225	+
SGLP	32	0.215	0.032	0.082	-

**Table 5.3 Chi-square value and intensity of use of different habitat types by hog deer based on direct sightings in winter ( $\chi^2 = 125.805, Z=2.6399$ )**

Habitat type	No. of groups sighted	Expected proportional Usage	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	54	0.265	0.117	0.227	-
PGLN	143	0.248	0.383	0.520	+
PGLP	57	0.132	0.125	0.238	*
SGLN	54	0.098	0.117	0.227	*
SGLP	6	0.215	0.000	0.039	-

**Table 5.4 Chi-square value and intensity of use of different habitat types by hog deer based on direct sightings in summer ( $\chi^2 = 91.273, Z=2.6399$ )**

Habitat type	No. of groups sighted	Expected proportional Usage	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	64	0.265	0.142	0.258	-
PGLN	147	0.248	0.388	0.531	+
PGLP	34	0.132	0.062	0.151	*
SGLN	49	0.098	0.101	0.205	*
SGLP	26	0.215	0.042	0.121	-

**Table 5.5 Chi-square value and overall intensity of use of different habitat types by hog deer based on indirect evidences ( $\chi^2 = 939.528, Z=2.5799$ )**

Habitat type	No. of pellet groups sighted	Expected proportional Usage	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	1482	0.265	0.303	0.339	+
PGLN	1545	0.248	0.317	0.353	+
PGLP	929	0.132	0.186	0.216	+
SGLN	245	0.098	0.045	0.062	-
SGLP	416	0.215	0.079	0.101	-

cases (overall, winter and summer). Result of pellet group counts showed that hog deer preferred RGL, PGLN, and SGLN. SGLN and SGLP were avoided. ( $p < 0.05$ ) (Table 5.5). Seasonal habitat use was also found to be similar, with preference for RGL, PGLN, and SGLN and avoidance of SGLN, and SGLP ( $p < 0.05$ ) (Table 5.6 & 5.7)

#### 5.4.2. Chital

##### 5.4.2.1 Direct sighting

Result on overall habitat use by chital showed that overall SGLN was preferred and PGLP and SGLP was used in proportion to their availability. Nothing could be stated about the utilization of RGL and PGLN since there was no sighting in either of these habitat types ( $p < 0.05$ ) (Table 5.8).

In winter also SGLN was preferred and rest of the habitat types had a similar trend with no sighting in RGL and PGLN ( $p < 0.05$ ) (Table 5.9)

Whereas in summer utilisation of different habitat types were in proportion to their availability. In summer also there was no sighting in RGL and PGLN (Table 5.10).

As stated earlier that very few chital were encountered during the whole study period. The only possible reason could be that chital is an introduced species at Jaldapara.

##### 5.4.2.2 Indirect

Results on habitat use by chital from pellet count were not found to be very different from direct sighting. The overall utilization of SGLP was more in proportion to its availability. PGLN was avoided and PGLP and SGLN was used in proportion to their availability. No pellet groups were encountered in RGL ( $p < 0.05$ ) (Table 5.11)

In summer PGLP was preferred and PGLN was avoided. SGLN and SGLP was used in proportion to their availability ( $p < 0.05$ ) (Table 5.12). In winter pellet groups were encountered only in SGLP and chital showed a preference for this habitat type (Exp. Prop. Use = 0.215, Confidence Interval = 0.328-0.687,  $Z = 2.63$ ,  $\chi^2 = 36.46$ )

**Table 5.6 Chi-square value and intensity of use of different habitat types  
By hog deer based on indirect evidences in winter ( $\chi^2 = 409.823, Z = 2.5799$ )**

Habitat type	No. of pellet groups sighted	Expected Proportional Usage	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	812	0.265	0.324	0.375	+
PGLN	695	0.248	0.275	0.324	+
PGLP	450	0.132	0.173	0.215	+
SGLN	132	0.098	0.044	0.069	-
SGLP	232	0.215	0.084	0.116	-

**Table 5.7 Chi-square value and intensity of use of different habitat types  
By hog deer based on indirect evidences in summer ( $\chi^2 = 572.144, Z = 2.5799$ )**

Habitat type	No. of pellet groups sighted	Expected proportional Usage	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	670	0.265	0.267	0.316	+
PGLN	850	0.248	0.344	0.396	+
PGLP	479	0.132	0.187	0.231	+
SGLN	113	0.098	0.038	0.061	-
SGLP	184	0.215	0.066	0.095	-

**Table 5.8 Chi-square value and overall intensity of use of different habitat types by chital based on direct sightings ( $\chi^2 = 23.284, Z = 2.6399$ )**

Habitat type	No. of groups sighted	Expected proportional	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	0	0.265	-	-	-
PGLN	0	0.248	-	-	-
PGLP	8	0.132	0.108	0.654	*
SGLN	9	0.098	0.150	0.707	+
SGLP	4	0.215	0.000	0.412	*

**Table 5.9 Chi-square value and intensity of use of different habitat types by chital based on direct sightings in winter ( $\chi^2 = 19.835, Z = 2.6399$ )**

Habitat type	No. of groups sighted	Expected proportional	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	0	0.265	-	-	-
PGLN	0	0.248	-	0.482	*
PGLP	2	0.132	0.158	0.933	+
SGLN	6	0.098	0.000	0.619	*
SGLP	3	0.215			

**Table 5.10 Chi-square value and intensity of use of different habitat types by chital based on direct sightings in summer ( $\chi^2 = 15.770, Z = 2.6399$ )**

Habitat type	No. of groups sighted	Expected proportional Usage	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	0	0.265	-	-	-
PGLN	0	0.248	-	-	-
PGLP	4	0.132	0.044	0.956	*
SGLN	3	0.098	0.000	0.817	*
SGLP	1	0.215	0.000	0.427	*

**Table 5.11 Chi-square value and overall intensity of use of different habitat types by chital based on indirect evidences ( $\chi^2 = 34.312, Z = 2.6399$ )**

Habitat type	No. of pellet groups sighted	Expected proportional usage	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	0	0.265	-	-	-
PGLN	2	0.248	0.000	0.154	-
PGLP	11	0.132	0.107	0.504	*
SGLN	6	0.098	0.006	0.327	*
SGLP	17	0.215	0.258	0.687	+

**Table 5.12 Chi-square value and intensity of use of different habitat types by chital based on indirect evidences in summer ( $\chi^2 = 28.468, Z = 2.6399$ )**

Habitat type	No. of pellet groups sighted	Expected proportional usage	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	0	0.265	-	-	-
PGLN	2	0.248	0.000	0.212	-
PGLP	11	0.132	0.173	0.673	+
SGLN	6	0.098	0.018	0.444	*
SGLP	7	0.215	0.045	0.494	*

**Table 5.13 Chi-square value and overall intensity of use of different habitat types by rhino based on direct sightings ( $\chi^2 = 48.694, Z = 2.6399$ )**

Habitat type	No. of direct sightings	Expected proportional usage	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	7	0.265	0.020	0.330	*
PGLN	3	0.248	0.000	0.182	-
PGLP	19	0.132	0.271	0.679	+
SGLN	9	0.098	0.055	0.395	*
SGLP	2	0.215	0.000	0.139	-

### 5.4.3. Rhino

#### 5.4.3.1 Direct sighting

The overall utilization of habitat types were different from expected. PGLP was preferred whereas PGLN and SGLP was avoided. RGL and SGLN was used in proportion to their availability ( $p < 0.05$ ) (Table 5.13)

In winter also PGLP was preferred by rhino. RGL and SGLN was used in proportion to their availability. No sightings were found in PGLN and SGLP in winter season ( $p < 0.05$ ) (Table 5.14)

In summer no trend in utilization of its habitat type was obtained since the results showed that all habitat types were used in proportion to their availability. ( $P < 0.05$ ) (Table 5.15 )

#### 5.4.3.2 Indirect sighting

Data on overall use of habitat type by rhino by indirect method showed that PGLP was preferred and PGLN was avoided. RGL and SGLN were used in proportion to their availability. No dung was encountered in SGLP ( $p < 0.05$ ) (Table 5.16). In winter, rhino showed a similar trend as above in its habitat use ( $p < 0.05$ ) (Table 5.17).

In summer rhino dung was encountered only in RGL and Neu *et al* (1974) method showed it to be used in proportion to its availability.

### 5.4. 4. Cattle

#### 5.4.4.1 Indirect

For cattle no data on direct sighting is available since they use to enter the sanctuary area by 10:00 AM and my encounter rates of animals used to start from 6:30 – 8:30 in winter and 5:00 - 8:00 in summer. So dung counts is the only systematic method which can give a clue on use of habitats by cattle. Though many times I have random encounters of cattle inside the sanctuary but I have not included it in this analysis. It was observed that cattle

preferred PGLN, avoided PGLP and used RGL in proportion to its availability ( $p < 0.05$ ) (Table 5.18)

In winter cattle preferred PGLN and used RGL in proportion to its availability. NO dung was encountered in SGLN, SGLP and PGLP ( $p < 0.05$ ) (Table 5.19)

In summer also cattle was found to prefer PGLN but avoided PGLP. RGL was used in proportion to its availability ( $p < 0.05$ ) (Table 5.20).

**Table 5.14 Chi-square value and intensity of use of different habitat types by rhino based on direct sightings in winter ( $\chi^2=60.688$ ,  $Z=2.6399$ )**

Habitat type	No. of direct sightings	Expected proportional usage	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	5	0.265	0.000	0.406	*
PGLN	0	0.248	-	-	-
PGLP	16	0.132	0.392	0.888	+
SGLN	4	0.098	0.000	0.349	*
SGLP	0	0.215	-	-	-

**Table 5.15 Chi-square value and intensity of use of different habitat types by rhino based on direct sightings in summer ( $\chi^2=6.175$ ,  $Z=2.6399$ )**

Habitat type	No. of direct sightings	Expected proportional use	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	2	0.265	0.000	0.360	*
PGLN	3	0.248	0.000	0.466	*
PGLP	3	0.132	0.000	0.466	*
SGLN	5	0.098	0.019	0.647	*
SGLP	2	0.215	0.000	0.360	*

**Table 5.16 Chi-square value and overall intensity of use of different habitat types by rhino based on indirect evidences ( $\chi^2=31.062$ ,  $Z=2.6399$ )**

Habitat type	No. of dung groups encountered	Expected proportional use	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	7	0.265	0.083	0.654	*
PGLN	1	0.248	0.000	0.185	-
PGLP	10	0.132	0.231	0.822	+
SGLN	1	0.098	0.000	0.185	*
SGLP	0	0.215	-	-	-

**Table 5.17 Chi-square value and overall intensity of use of different habitat types by rhino based on indirect evidences in winter ( $\chi^2=38.846$ ,  $Z=2.6399$ )**

Habitat type	No. of dung groups encountered	Expected proportional	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	3	0.265	0.000	0.466	*
PGLN	1	0.248	0.000	0.233	-
PGLP	10	0.132	0.353	0.981	+
SGLN	1	0.098	0.000	0.233	*
SGLP	0	0.215	-	-	-

**Table 5.18 Chi-square value and overall intensity of use of different habitat types by cattle based on indirect evidences ( $\chi^2=88.660$ ,  $Z=2.6399$ )**

Habitat type	No. of dung groups encountered	Expected proportional use	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	32	0.265	0.241	0.512	*
PGLN	52	0.248	0.475	0.748	-
PGLP	1	0.132	0.000	0.042	+
SGLN	0	0.098	-	-	-
SGLP	0	0.215	-	-	-

**Table 5.19 Chi-square value and intensity of use of different habitat types by cattle based on indirect evidences in winter ( $\chi^2=42.931$ ,  $Z=2.639$ )**

Habitat type	No. of dung groups encountered	Expected proportional use	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	13	0.265	0.149	0.554	*
PGLN	24	0.248	0.446	0.851	+
PGLP	0	0.132	-	-	-
SGLN	0	0.098	-	-	-
SGLP	0	0.215	-	-	-

**Table 5.20 Chi-square value and intensity of use of different habitat types by cattle based on indirect evidences in summer ( $\chi^2=46.317$ ,  $Z=2.639$ )**

Habitat type	No. of dung groups encountered	Expected proportional use	Confidence Interval		Intensity Of Use
			LL	UL	
RGL	19	0.265	0.214	0.578	*
PGLN	28	0.248	0.400	0.767	+
PGLP	1	0.132	0.000	0.074	-
SGLN	0	0.098	-	-	-
SGLP	0	0.215	-	-	-

## 5.5 Selection of habitat attributes by hog deer

### 5.5.1. Grass phenology

The overall utilization of fresh sprouts, young shoots and matured grass was done on a seasonal basis. The results were found to be significantly different from their expected utilization.

In winter areas with fresh sprouts of grasses were used in proportion to their availability. Whereas areas with, young shoots were avoided and matured grasses were preferred ( $p < 0.05$ ) (Table 5.21).

In summer areas with fresh sprouts and young shoots of grasses were preferred, while areas with matured grasses were avoided ( $p < 0.05$ ) (Table 5.22).

Once the results of overall grass phenology preferred by hog deer was obtained data was analysed separately for each forage or grass category separately across different habitat types. This also gave an idea about the overall availability of each variable in each habitat type. Results of each phenological classes are summarised below on a seasonal basis :

#### *In winter:*

##### 1. Fresh sprouts

On analysing data on use of areas with fresh sprouts in different habitat types, it was observed that in winter Hog deer preferred areas with fresh sprouts of grasses in PGLN and SGLN, but avoided such areas in PGLP and SGLP ( $P < 0.05$ ). Whereas in RGL areas with fresh sprouts were used in proportion to their availability (Table 5.23).

##### 2. Young shoots

On analysing data on young shoots it was found that utilization of areas with young shoots was not in proportion to their availability. Areas with young shoots of grasses were preferred only in SGLN, whereas avoided in RGL and SGLP ( $p < 0.05$ ). In PGLN and PGLP young shoots were used in proportion to their availability (Table 5.24).

**Table 5.21 Chi-square value and overall intensity of use of different phenophase of grasses by hog deer in winter ( $\chi^2=45.25, Z=2.579$ ).**

Phenophase	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
FS	0.395	0.414	0.364	0.462	*
YS	0.514	0.173	0.136	0.211	-
M	0.091	0.412	0.364	0.462	+

**Table 5.22 Chi-square value and overall intensity of use of different phenophase of grasses by hog deer in summer ( $\chi^2=1113.678, Z=2.579$ ).**

Phenophase	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
FS	0.133	0.597	0.546	0.649	+
YS	0.143	0.253	0.208	0.300	+
M	0.725	0.148	0.111	0.186	-

**Table 5.23 Chi-square value and intensity of use of Fresh Sprouts of grasses in different habitat types in winter ( $\chi^2=120.64, Z=2.5799$ ).**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
RGL	0.139	0.167	0.105	0.230	*
PGLN	0.377	0.631	0.551	0.712	+
PGLP	0.286	0.079	0.034	0.125	-
SGLN	0.049	0.104	0.054	0.156	+
SGLP	0.146	0.016	0.000	0.038	-

**Table 5.24 Chi-square value and intensity of use of Young shoots of grasses in different habitat types in winter ( $\chi^2=45.88, Z=2.5799$ ).**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
RGL	0.333	0.140	0.050	0.230	-
PGLN	0.263	0.361	0.236	0.484	*
PGLP	0.134	0.201	0.097	0.303	*
SGLN	0.129	0.280	0.164	0.396	+
SGLP	0.140	0.020	0.000	0.056	-

**Table 5.25 Chi-square value and intensity of use of matured grasses in different habitat types in winter ( $\chi^2=1151.33, Z=2.5799$ ).**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
RGL	0.121	0.189	0.124	0.255	+
PGLN	0.121	0.247	0.176	0.320	+
PGLP	0.030	0.331	0.253	0.411	+
SGLN	0.030	0.205	0.138	0.274	-
SGLP	0.697	0.025	0.000	0.051	-

### 3. Matured shoots

Results showed that utilization of matured shoots were not in proportion to their availability. Areas with matured grasses were preferred in RGL, PGLN and PGLP whereas avoided in SGLN and SGLP ( $p < 0.05$ ) (Table 5.25).

*In summer:*

#### 1. Fresh sprouts

Areas with fresh sprouts in PGLN, SGLN and SGLP were preferred by hog deer. Areas with fresh sprouts of grasses in RGL were avoided, and areas with fresh sprouts of grasses in PGLP were used in proportion to their availability ( $p < 0.05$ ) (Table 5.26)

#### 2. Young shoots

Young shoots in PGLN were used more in proportion to their availability and avoided in SGLN and SGLP. Areas with young shoots in RGL and PGLP was used in proportion to their availability ( $p < 0.05$ ) (Table 5.27).

#### 3. Matured shoots

Matured shoots in summer all habitat types were used in proportion to their availability except in SGLN where it showed avoidance ( $p < 0.05$ ) (Table 5.28).

#### 5.5.2. Escape cover or grass height

Overall use of different grass height for cover was analysed on a seasonal basis to find out the cover category most preferred by hog deer. Null hypothesis was rejected in both the seasons.

Both in winter and summer overall use of cover class II, III and IV was preferred where as class I was avoided ( $p < 0.05$ ) (Table 5.29 & Table 5.30). Though this analysis gave the over all preference of cover by hog deer in each habitat it did not explain the variation of use in each habitat type.

**Table 5.26 Chi-square value and intensity of use of Fresh Sprouts of grasses in different habitat types in Summer ( $\chi^2=518.460, Z=2.57990$ )**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
RGL	0.537	0.156	0.103	0.211	-
PGLN	0.366	0.486	0.413	0.561	+
PGLP	0.049	0.062	0.026	0.098	*
SGLN	0.024	0.189	0.132	0.247	+
SGLP	0.024	0.104	0.059	0.150	+

**Table 5.27 Chi-square value and intensity of use of Young shoots of grasses in different habitat types in Summer ( $\chi^2=20.565, Z=2.5799$ )**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
RGL	0.409	0.346	0.239	0.454	*
PGLN	0.250	0.400	0.289	0.511	+
PGLP	0.091	0.115	0.043	0.188	*
SGLN	0.159	0.076	0.017	0.137	-
SGLP	0.091	0.061	0.007	0.116	-

**Table 5.28 Chi-square value and intensity of use of matured grasses in different habitat types in Summer ( $\chi^2=8.953, Z=2.5799$ )**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
RGL	0.299	0.302	0.167	0.439	*
PGLN	0.321	0.368	0.226	0.511	*
PGLP	0.179	0.250	0.122	0.378	*
SGLN	0.085	0.013	0.000	0.047	-
SGLP	0.116	0.065	0.000	0.139	*

**Table 5.29 Chi-square value and overall intensity of use of different grass height class in winter ( $\chi^2=432.446, Z=2.5799$ ).**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
Class I	0.788	0.318	0.253	0.344	-
Class II	0.123	0.353	0.286	0.420	+
Class III	0.068	0.246	0.186	0.307	+
Class IV	0.020	0.082	0.043	0.121	+

**Table 5.30 Chi-square value and overall intensity of use of different grass height class in in summer ( $\chi^2=142.874, Z=2.5799$ ).**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
Class I	0.660	0.414	0.346	0.483	-
Class II	0.245	0.320	0.256	0.386	+
Class III	0.072	0.180	0.127	0.234	+
Class IV	0.023	0.084	0.045	0.123	+

Hence data for availability and utilization of areas with each cover class in each habitat type was compared for each season, the results are summarised below :

**In winter:**

**1. Cover height class I (1-50cm)**

On analysing data on utilization of cover class I in different habitat types results were found to be significantly different from expected results. Use of this cover category was more only in PGLN but avoided in RGL and PGLP. In SGLN and SGLP this cover category was used in proportion to their availability ( $p < 0.05$ ) (Table 5.31).

**2. Cover height class II ( 50 – 100cm )**

Cover height class II was preferred in PGLN, PGLP and SGLN whereas avoided in RGL and SGLP ( $p < 0.05$ ) (Table 5.32)

**3. Cover height class III (100-200 cm)**

Utilization of cover height class III was significantly different from expected, hence null hypothesis was rejected. Cover of 50-100 cm was preferred in PGLN and PGLP, whereas avoided in RGL and SGLP. In SGL this cover category was used in proportion to their availability ( $P < 0.05$ ) (Table 5.33)

**3. Cover height class IV (>200cm)**

Grass height or grass cover >200 cm was preferred as a cover in PGLP whereas avoided in RGL. In rest of the habitat types i.e., PGLN, SGLN, and SGLP this category of grass was used as escape cover in proportion to their availability ( $p < 0.05$ ) (Table 5.34)

**Table 5.31 Chi-square value and intensity of use of grass height class I in different habitat types in winter ( $\chi^2=39.339, Z=2.5799$ ).**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
RGL	0.240	0.157	0.037	0.177	-
PGLN	0.329	0.719	0.376	0.601	+
PGLP	0.182	0.078	0.003	0.104	-
SGLN	0.093	0.146	0.032	0.167	*
SGLP	0.157	0.033	0.154	0.350	*

**Table 5.32 Chi-square value and intensity of use of grass height class II in different habitat types in winter ( $\chi^2=266.657, Z=2.5799$ ).**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
RGL	0.571	0.116	0.030	0.194	-
PGLN	0.143	0.428	0.308	0.549	+
PGLP	0.020	0.169	0.078	0.261	+
SGLN	0.102	0.258	0.152	0.366	+
SGLP	0.163	0.026	0.000	0.066	-

**Table 5.33 Chi-square value and intensity of use of grass height class III in different habitat types in winter ( $\chi^2=250.806, Z=2.5799$ ).**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
RGL	0.789	0.256	0.129	0.384	-
PGLN	0.037	0.333	0.196	0.471	+
PGLP	0.074	0.243	0.118	0.369	+
SGLN	0.074	0.153	0.048	0.259	*
SGLP	0.111	0.012	0.000	0.046	-

**Table 5.34 Chi-square value and intensity of use of grass height class IV in different habitat types in winter ( $\chi^2=41.4615, Z=2.5799$ ).**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
RGL	0.500	0.269	0.045	0.494	-
PGLN	0.125	0.115	0.000	0.277	*
PGLP	0.125	0.538	0.286	0.791	+
SGLN	0.125	0.038	0.000	0.136	*
SGLP	0.125	0.038	0.000	0.137	*

In Summer:

**1. Grass cover I (1-50 cm)**

In PGLN and SGLN grass height of 1-50 cm was preferred as cover whereas it was avoided in RGL and PGLP. In SGLP utilization of areas with grass height between 1-50 cm as cover was done in proportion to their availability ( $p < 0.05$ ) (Table 5.35).

**2. Cover class II (50- 100 cm)**

Cover of class II is preferred in PGLN and avoided in PGLP and SGLP. In RGL and SGLN this category of cover is used in proportion to their availability ( $p < 0.05$ ) (Table 5.36).

**3. Cover class III (100-200 cm)**

Hog deer preferred grass height class III as cover only in PGLN and avoided in RGL. In all other habitat types it was used in proportion to their availability ( $p < 0.05$ ) (Table 5.37)

**4. Cover class IV (> 200 cm)**

On analysing data on observation of Hog deer in grass height class IV it was observed that this height class was used as cover in all habitat types in proportion to their availability. Hence I failed to reject the null hypothesis ( $p < 0.05$ ) (Table 5.38).

**5.5.3. Burnt areas**

On analysis data on overall utilization of burnt areas it was found that burnt areas were avoided in winter and preferred in summer (5.39).

Burnt areas in

*winter*, were preferred in PGLN and SGLN but avoided in RGL and PGLP. In SGLP burnt areas were used in proportion to their availability ( $p < 0.05$ ) (Table 5.40)

*summer*, were preferred in PGLN and SGLN but avoided in PGLP and SGLP. In RGL burnt areas were used in proportion to their availability ( $p < 0.05$ ) (Table 5.41).

**Table 5.35 Chi-square value and intensity of use of grass height class I in different habitat types in summer ( $\chi^2=65.412, Z=2.5799$ )**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
RGL	0.307	0.090	0.026	0.154	-
PGLN	0.307	0.481	0.369	0.593	+
PGLP	0.125	0.045	0.000	0.092	-
SGLN	0.102	0.240	0.145	0.336	+
SGLP	0.159	0.142	0.065	0.221	*

**Table 5.36 Chi-square value and intensity of use of grass height class II in different habitat types in summer ( $\chi^2=50.33, Z=2.5799$ )**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
RGL	0.235	0.213	0.109	0.318	*
PGLN	0.276	0.504	0.378	0.632	+
PGLP	0.255	0.087	0.016	0.159	-
SGLN	0.082	0.165	0.071	0.259	*
SGLP	0.153	0.029	0.000	0.072	-

**Table 5.37 Chi-square value and intensity of use of grass height class III in different habitat types in summer ( $\chi^2=62.375, Z=2.5799$ )**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
RGL	0.621	0.362	0.199	0.525	-
PGLN	0.103	0.413	0.247	0.581	+
PGLP	0.138	0.155	0.033	0.278	*
SGLN	0.034	0.017	0.000	0.061	*
SGLP	0.103	0.051	0.000	0.127	*

**Table 5.38 Chi-square value and intensity of use of grass height class IV in different habitat types in summer ( $\chi^2=15.583, Z=2.5799$ )**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
RGL	0.444	0.333	0.099	0.567	*
PGLN	0.222	0.259	0.042	0.477	*
PGLP	0.11	0.333	0.099	0.567	*
SGLN	0.111	0.037	0.000	0.131	*
SGLP	0.111	0.037	0.000	0.131	*

**Table 5.39 Chi-square value and overall intensity of use of burnt areas by hog deer in summer and winter ( $\chi^2 = 9.479$ ,  $Z = 2.5799$ )**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
Winter	0.417	0.333	0.0280	0.392	-
Summer	0.583	0.259	0.608	0.720	+

**Table 5.40 Chi-square value and intensity of use of burnt areas in different habitat types in winter ( $\chi^2 = 144.914$ ,  $Z = 2.5799$ )**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
RGL	0.374	0.201	0.107	0.297	-
PGLN	0.433	0.714	0.607	0.821	+
PGLP	0.182	0.008	0.000	0.030	-
SGLN	0.005	0.067	0.008	0.126	+
SGLP	0.005	0.008	0.000	0.030	*

**Table 5.41 Chi-square value and intensity of use of burnt areas in different habitat types in summer ( $\chi^2 = 84.948$ ,  $Z = 2.5799$ )**

Habitat	Proportion		Confidence Interval		Intensity of Use
	Availability	Utilized	LL	UL	
RGL	0.162	0.136	0.078	0.194	*
PGLN	0.349	0.519	0.435	0.603	+
PGLP	0.204	0.076	0.032	0.121	-
SGLN	0.095	0.200	0.133	0.267	+
SGLP	0.190	0.068	0.026	0.110	-

## 5.6 Disturbance

### 5.6.1 Cutting

Disturbance in terms of cutting was found to be maximum in PGLP ( $0.495 \pm 0.16$ ) followed by PGLN ( $0.355 \pm 0.07$ ) and minimum in SGLP ( $0.216 \pm 0.07$ ) ( Fig 5.5). Overall variation of grass cutting across different habitat type was found to be significantly different (KW  $\chi^2 = 8.990$ , df = 4, p=0.061, n=261). An overall analyses of use of cut and uncut areas by hog deer was also done to check how it influences the overall habitat selection by hog deer, results are given below :

Pellet group densities were used as an index to quantify the use of these area. It was observed that overall pellet group density of hog deer in cut areas were found to be significantly different from uncut areas. (KW  $\chi^2 = 15.152$ , df = 4, p=0.004, n=264). On analysing for each habitat type it was observed that the difference in pellet group density between cut –uncut area's was significant only in PGLN habitat type (KW  $\chi^2 = 4.683$ , df = 1, p=0.03, n= 74). (Fig. 5.6). Availability - utilization comparison could not be done in case of cut - uncut area because it was not possible to quantify this variable for each and every direct sighting I had.

### 5.6.2 Burning

Occurrence of fire was found to be maximum in PGLN ( $0.70 \pm 0.03$ ) and minimum in (RGL  $0.22 \pm 0.04$ ) (Fig 5.7.1). The variation in average number of burnt plots was in different habitat type was found to be significant (KW  $\chi^2 = 56.100$ , df = 4, p=0.000, n=264). Incidences of fire was also found to be more in summer ( $0.68 \pm 0.03$ ) compared to winter ( $0.16 \pm 0.02$ ) (Fig 5.7.2) and the difference was significant (KW  $\chi^2 = 93.502$ , df = 1, p=0.000, n=264)

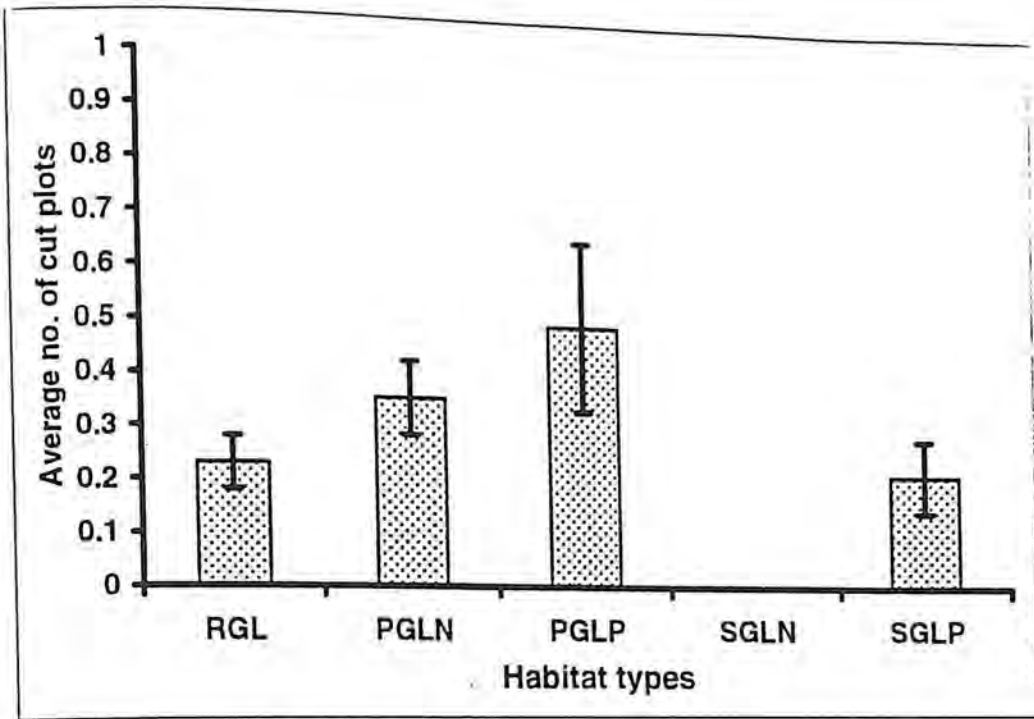


Fig 5.5 Average number of cut plots in each habitat types

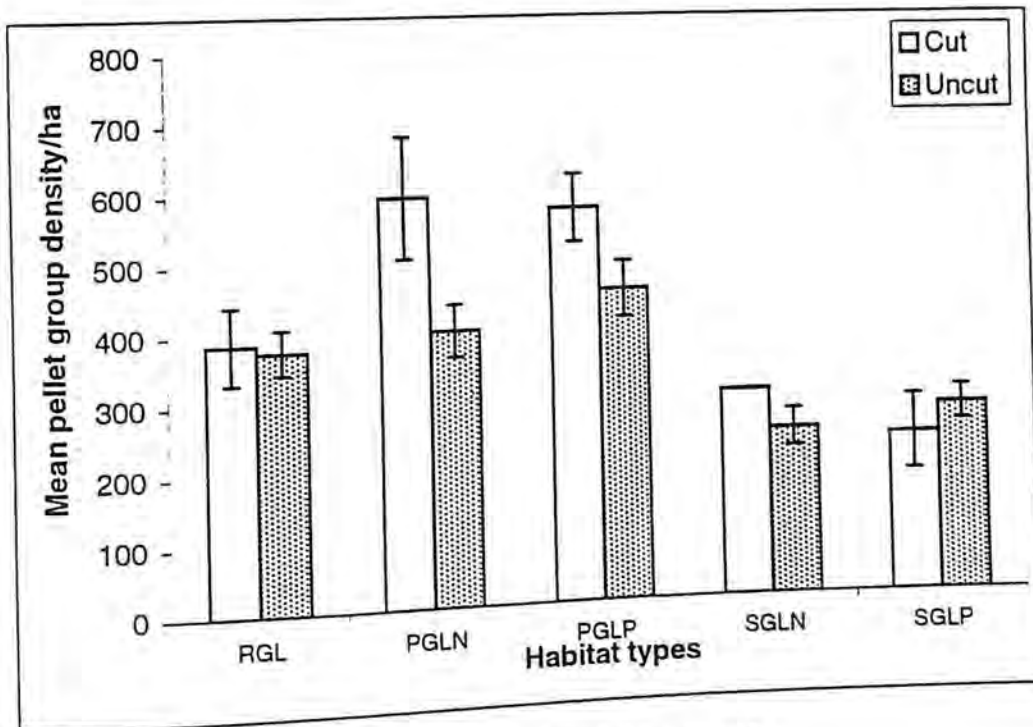


Fig. 5.6 Mean pellet group density of hog deer in cut areas in different habitat types

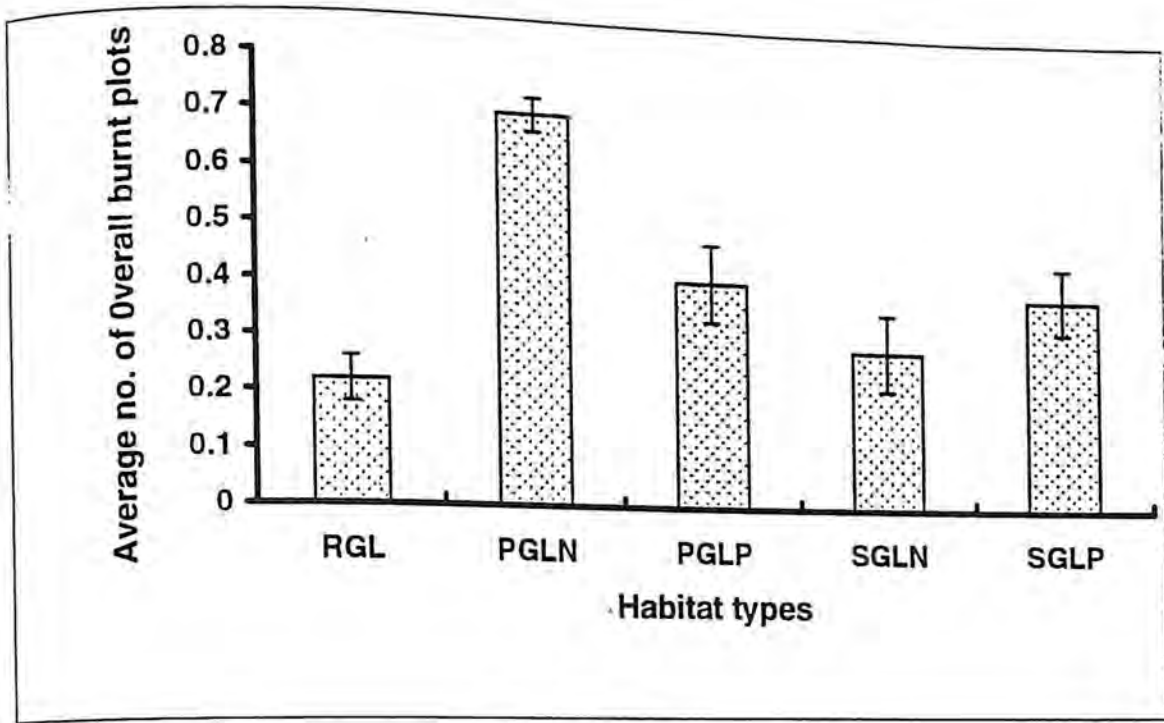


Fig 5.7.1 Average number of burnt plots in each habitat type

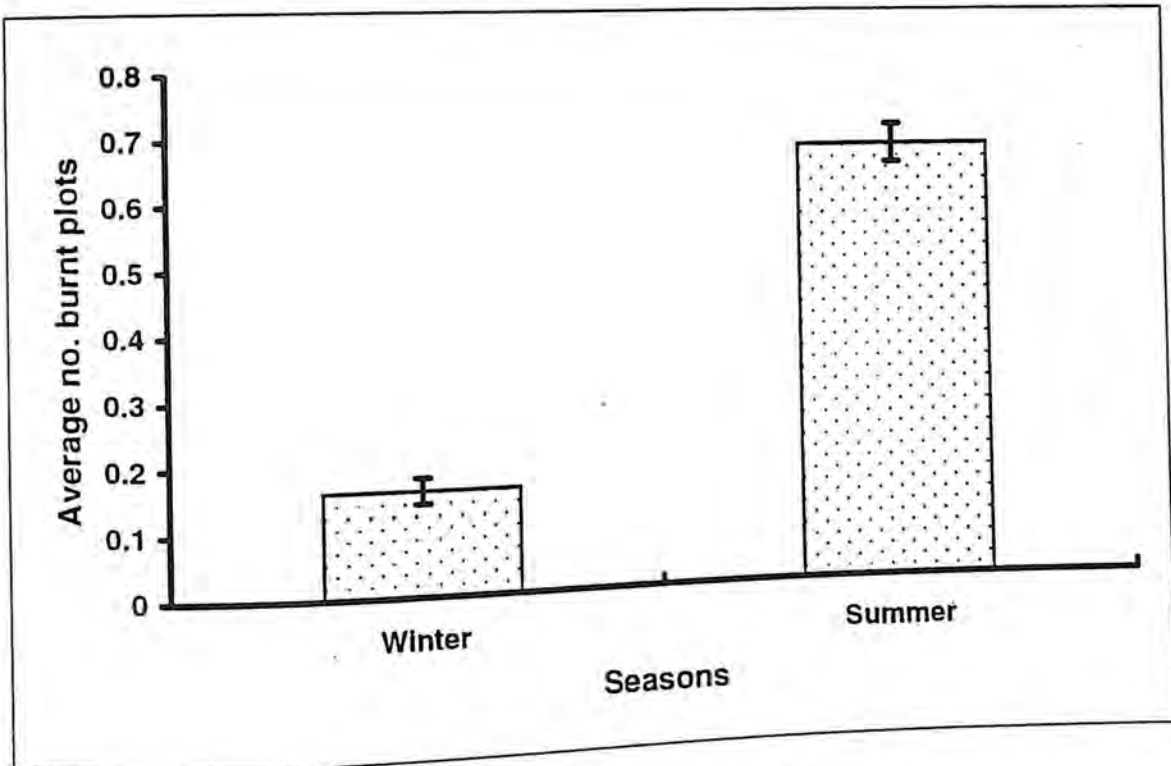


Fig 5.7.2 Average number of burnt plots in winter and summer.

### 5.6.3 Cattle dung density

Cattle dung density was also found to be maximum in PGLN and minimum in SGLP. Results in details have already been discussed in section 5.3.4.

## 5.7 Habitat degradation

### 5.7.1 Weed invasion

Weed density/ha was observed to be maximum in PGLP ( $6490.74 \pm 1851$ ,  $n=21$ ) and minimum in RGL ( $818.92 \pm 374.93$ ,  $n=28$ ) (Fig. 5.8). The variation in mean density of weeds /ha was found to be significant ( $KW \chi^2 = 63.16$ ,  $df=4$ ,  $p=0.000$ ,  $n=127$ )

### 5.7.2 Woodland encroachment

#### 1. Seedling (> 1 cm)

Mean density of seedling was maximum in PGLN ( $1001.89 \pm 165.37$ ,  $n=37$ ) and minimum in SGLN ( $348.80 \pm 79.67$ ,  $n=21$ ) (Fig. 5.9.1) The variation in mean seedling density/ ha was found to be significantly different ( $KW \chi^2 = 18.32$ ,  $df=4$ ,  $p=0.001$ ,  $n=126$ ).

#### 2. Sapling (1-5 cm)

Mean density/ha of sapling (1-5 cm GBH class) was found to be maximum in PGLN ( $611.62 \pm 54.37$ ,  $n=39$ ) and minimum in SGLP ( $320.746 \pm 30.333$ ,  $n=28$ ) (Fig. 5.9.1). The overall variation in mean sapling density across different habitat types was found to be significant ( $p < 0.05$ ) ( $KW \chi^2 = 18.01$ ,  $df=4$ ,  $p=0.001$ ,  $n=147$ ).

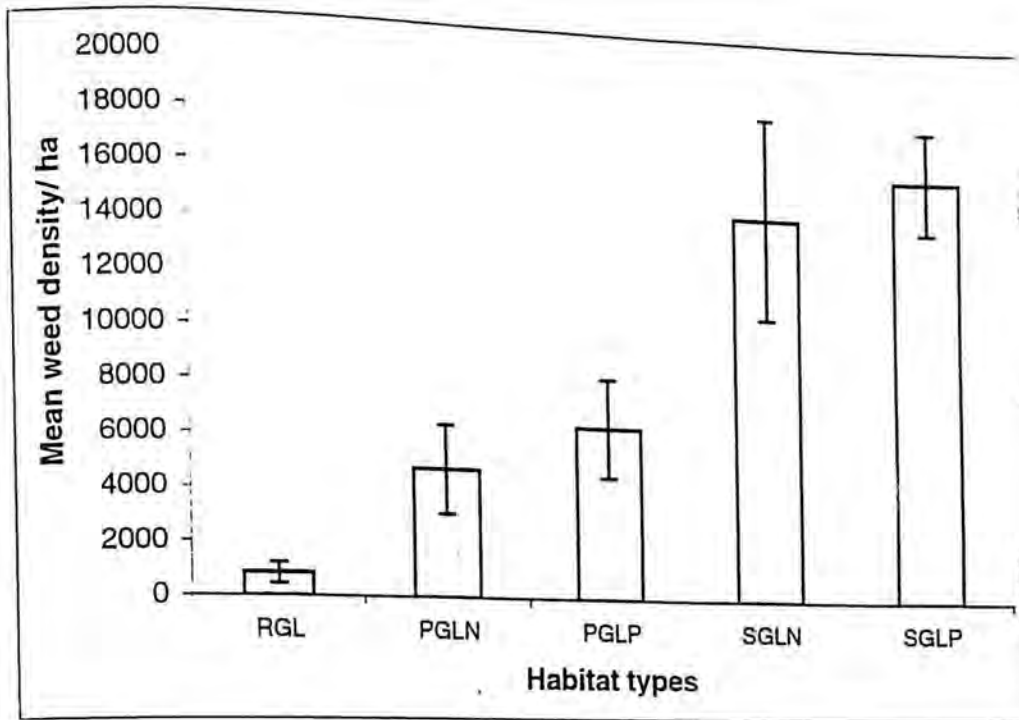


Fig. 5.8 Mean density of weeds in different habitat types.

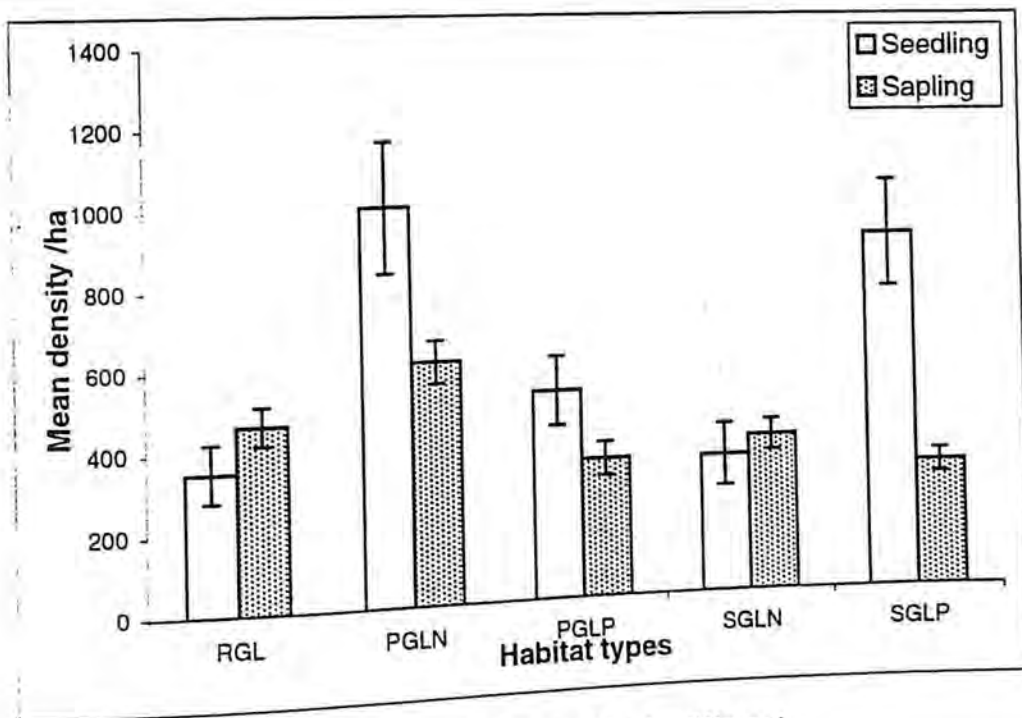


Fig 5.9.1 Mean seedling and sapling density in different habitat types

### **3. Recruitment class (GBH 5-10 cm)**

Mean density of recruitment class was found to be maximum in SGLN ( $48.528 \pm 11.75$ ,  $n=21$ ) and minimum in PGLP ( $7.582 \pm 3.74$ ,  $n=21$ ) (Fig 5.9.2). The overall variation in density of recruitment class across different habitat type was found to be significant.

(KW  $\chi^2 = 27.369$ ,  $df= 4$ ,  $p=0.000$ ,  $n=127$ ). Mean density of recruitment class in PGLN was found to be zero.

### **4. Pole ( GBH 10- 20 cm )**

Mean density of pole class was maximum in SGLP ( $9.099 \pm 5.21$ ,  $n=20$ ) and minimum in RGL ( $4.549 \pm 2.14$ ,  $n=28$ ) (Fig 5.9.2). No trees belonging to this class was found in PGLP.

The variation is significant (KW  $\chi^2 = 10.708$ ,  $df=4$ ,  $p=0.03$ ,  $n=127$ )

### **5. Trees density (>20 cm GBH )**

Mean tree density /ha was maximum in SGLP ( $68.11 \pm 12.37$ ,  $n=36$ ) and minimum in PGLP ( $9.099 \pm 3.21$ ,  $n=21$ ) (Fig 5.9.2). The over all variation in mean tree density/ha was found to be significant across different habitat types ( $p<0.05$ ). (KW  $\chi^2 = 41.978$ ,  $df=4$ ,  $p=0.000$ ,  $n=168$ ).

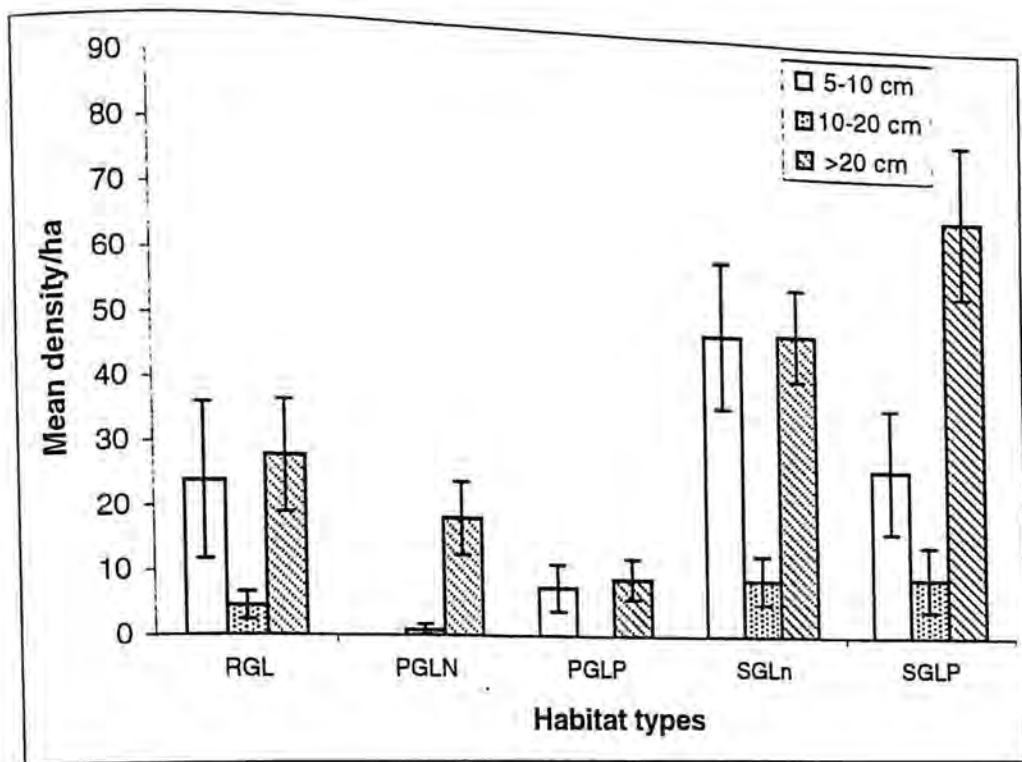


Fig. 5.9.2 Density of mean recruitment (5-10 cm) class, pole (11-20 cm) and tree (> 20 cm) in different habitat types.

## Chapter 6

### Discussion

Habitat selection by a species is the result of the intrinsic characteristics of the species and the inherent features of the habitat it occupies. The results of this study are accord with the theoretical predictions concerning habitat use by small bodied ungulates (Jarman & Sinclair 1979). In a similar study on hog deer (Gara 1991) it was found that density was maximum in flood plain grassland. Since the above study concentrated on the overall ecology of hog deer so it gave a general idea of habitat utilization by hog deer. However the present study is mainly concerned with the evaluation of different habitats used by hog deer, accordingly the results are summarized and discussed in terms of different habitat types for winter and summer to ascertain the effect of season on utilization of these habitats. Thus it also gives an idea about the seasonal requirement of the concerned species. Since the study mainly aims in quantifying availability and utilization of different habitat variables which may in turn affect habitat selection or rejection, no attempt has been made to identify the grassland communities.

#### 6.1 Overall selection of habitat and its parameters by hog deer

##### 6.1.1 Selection of habitat in summer and winter

Results of direct method showed that hog deer preferred PGLN and avoided SGLP and RGL both in winter and summer. Though PGLN was preferred in both the seasons, the overall mean abundance was low because most of the sightings were of solitary animals. Sometimes in winter at the most 2 individuals were sighted together in PGLN. However in summer in few cases 10 - 12 individuals were seen in a group. Such variation in mean abundance of hog deer in PGLN both in summer and winter was because of small group size which in turn reflects the proportion of escape cover available in that habitat type (Jarman 1984). Gara (1991) had reported an average

group size of 1.8 from 720 random observation of hog deer in Chitwan. On the other hand though SGLP was avoided by hog deer the overall mean abundance in both the seasons was found to be maximum because most of the groups sighted consisted of 7-8 individuals in winter and 15-16 in summer. On one or two occasions large groups up to 20 individuals were also encountered in SGLP. Though there was not much difference in availability of escape cover at 50 cm from the ground between PGLN and SGLP in both the seasons, the cover at 100 cm and 150 cm in PGLN was more than that in SGLP. In fact escape cover at 50 cm was more in SGLP in winter than in PGLN. Such difference in cover was there in winter because SGLP had maximum abundance of *Mikania scandens* (12.39% in winter, 6.95% in summer) the most dominant weed within the sanctuary. At places it was found to cover grasses and even trees up to the height of 2m. In many places it was seen that mikania was being selectively used as cover by hog deer. Even in grasslands with mikania, hog deer when disturbed were found to move into it since mikania provides 90% cover in SGLP and the animals could hide themselves. In summer it was seen that mikania was also used as bedding ground for fawns.

The other possible reason for encountering large groups in SGLP was its location. Most of the savanna grasslands (natural and plantation) were adjacent to patches of grassland (plantation and natural). In most cases these large groups were encountered during morning hours when they were seen moving towards the forest or dense vegetation areas after early morning grazing peak. As already stated in many cases hog deers encountered in this habitat were found to be resting and flushed all of a sudden because of detection of my presence. Gara (1991) has also reported that hog deer are mostly active in early morning and late evening hours. Since the animal sampling was not done on an diurnal scale, it gives a partial information about the active period of animals. Such encounters were common in winter since grasses were tall and forage availability was low. Hog deer in Jaldapara were found to be active only for a

very short period of time. Mostly in early mornings and evening hours sightings were maximum, during the rest of the day they were hardly seen, except for summer when I was able to have some opportunistic sightings of hog deer feeding in some of the burnt areas even during the day time.

### 6.1.2 Selection of grass phenophase in summer and winter

#### a. *Winter*

In winter it was observed that overall, hog deer showed an avoidance for young sprouts and indicated preference for matured shoots. The fresh sprouts were used in proportion to their availability. In winter most of the grasses were mature and hence were low in nutrient content. The digestibility of a forage plant and therefore its nutrient value is a function of its protein and fibre content (Geist 1974, Jarman 1974). Protein content is highest and fibre content is lowest in newly emerged plant tissues, which is the most nutritious phenophase (Jarman 1974). In this regard, plant parts and phenological stages are given importance when optimal foraging theory is applied to ungulates (Owen-Smith and Novellie 1982). Fresh grass sprouts have a high nutritive value which decreases as the grass matures. The energy and protein requirements of mammals are a function of their weight raised to the power of 0.75 (Geist 1974, Gordan 1989a). Therefore, smaller mammals have relatively higher requirements per unit body weight. Hog deer is considered to be a medium sized ungulate. Therefore hog deer is expected to have a relatively high metabolic energy requirement. Since graminoids have a relatively higher fibre content, browse species in general are more nutritious (Dinerstein 1987). Hence hog deer might be expected to be a browser. Instead it is a grazer because in medium sized ungulates such as the hog deer there is a high rumen size to body size ratio (Dinerstein 1987). A high rumen volume allows a slower turnover rate which is necessary for the digestion of grasses which is true in case of hog deer. Due to lack of any study on hog deer, speculation about its physiology can be made

from similar medium bodied grazer. Hog deer also have a high metabolic energy requirement, similar to other medium bodied ungulates which restricts its movement over long distances or spend much energy in search for food (Geist 1974, Gordan 1989a). Hence selection of any habitat type by hog deer will be such that it is able to achieve all its requirement with minimum effort (food, cover and shelter). However in winter as evident from observations, the effort had to be increased since overall availability of fresh sprouts which are most nutritious was quite low. So hog deer was expected to show preference for areas with fresh sprouts and good cover. In Jaldapara it appeared that hog deer have separate feeding and resting grounds because in areas where they were sighted feeding during early morning hours did not have sufficient cover, nor were they found in those areas during the rest of the day. Compared to the overall availability in winter young shoots were avoided since they were low in nutrient content and matured grasses were preferred because they were used as escape cover. The fresh sprouts were used in proportion to their availability because they had a patchy distribution and hog deer had to invest more time and energy in searching these. It also explains the overall avoidance of SGLP with 69% of matured grasses and 14% of both fresh sprouts and young shoots. This further explains the possible use of this habitat more as resting area than feeding sites.

#### ***b. Summer***

In summer it was observed that overall, hog deer showed an avoidance for matured shoots and preference for both fresh and young sprouts. Such variation in selection of fresh sprouts and avoidance of matured grasses occurred in summer because of anthropogenic fires and rain. During the summer rain was quite frequent and there was as a result sudden spurt of growth of fresh sprouts in all burnt areas. Burning in combination with moisture and rain enhanced the growth of grasses and hence influenced the availability. Since fresh sprouts are highly nutritious hog deer favoured

the highly nutritious diet of fresh sprouts and young shoots. Though burning increased the availability of highly nutritious forage at the same time it resulted in sudden loss of cover. Since matured grasses were mostly used by hog deer as cover, burning reduced their availability which in turn influenced the habitat use.

### **6.1.3 Selection of escape cover in summer and winter**

Summarising information on utilization of different cover classes it was observed that hog deer preferred cover class II, III and IV and avoided class I both in winter and summer. Among the three cover categories preferred, class II and III were expected to have maximum influence on habitat use by hog deer in terms of cover since they are heavy set and compact, standing only 27 to 28 inches (65-70 cm) high at the shoulder (Jerdon 1874). So the grass height 51-100 cm (class II) and 100-150 cm (class III) provide the ideal cover conditions for hog deer. Since class I (1-50 cm) is almost equal to the height of the deer so it is not used much as cover. There also appeared to be some particular pattern in use of different cover categories. Fawns were observed to use cover class I whenever they were encountered by themselves. Whereas fawns accompanied by mother were found to use class II, adult males and females were found to use class III and at times also class IV.

### **6.1.4 Selection of burnt areas in summer and winter**

Overall usage of burnt area was found to be different from its availability because in summer burnt areas were found to be used more than available whereas in winter such areas were utilized less in proportion to their availability. In summer burnt areas were preferred because burning was followed by rain which enhanced the growth of fresh sprouts which are a preferred forage phenophase for hog deer. Also in summer large areas were subjected to burns as compared to those in winter thus influencing the availability of fresh sprouts. In winter, the proportion of burnt areas was low and also

there was no rain for the whole season to initiate growth of grasses. As a result burning in winter was detrimental to hog deer in terms of loss of not only cover but also for food.

## 6.2 Seasonal preference of habitats

### *Winter selection - influenced by water*

Though both in summer and winter PGLN was found to be preferred, the possible causes of such selection are different. In winter PGLN was preferred because proportion of fresh sprouts were maximum in PGLN (37%) and it was also observed that hog deer selected fresh sprouts in PGLN (Table 5.23) Fresh sprouts were in large proportion in PGLN because of availability of water in winter. Among all the habitat types natural grasslands were the only habitat with availability of water throughout the year. Located in the older course of river Torsa these habitats are well traversed by natural streams and channels. There are many check dams constructed by the forest department which helps in conservation of moisture along the natural streams throughout the year and helps to maintain growth of fresh sprouts. Though matured grass in this habitat type was only 12.1% yet it was observed that hog deer selected areas with matured grasses in this habitat type (Table 5.25) since they provided good escape cover. This is further supported by the overall information available on grass cover (Table 5.29 & 5.30). Though overall, hog deer shows avoidance of class I in PGLN the maximum proportion of grass cover belonged to this class and hog deer preferred this cover class in addition to class II and III. It is difficult to explain such pattern in a short study like this. It would be necessary to have a much longer study to understand the seeming contradiction. Though escape cover was maximum only at 50 cm, there was availability of cover both at 100cm and 150cm respectively in proportion of 41.4% and 9% . Though in winter it was observed that hog deer avoided burnt areas but in PGLN it played a positive role. Burnt areas in winter were found to be preferred by

hog deer in PGLN since presence of moisture or water influenced the growth of grasses even in absence of rain. Thus *selection of natural grassland* by hog deer in *winter* was mainly because of availability of both forage (fresh sprouts), cover (matured grasses, escape cover and general cover) and water.

***b. Summer selection - influence of fire***

In summer PGLN was burnt and there was an immediate change in habitat use. It is a well known fact that burning initiates growth of grasses. Hence all these areas had sudden availability of fresh sprouts, but their utilization was governed by availability of cover. Since hog deer has an overall preference for escape cover category II, III and IV and avoidance for class I as cover so availability of the latter three classes determined the selection of habitat. In summer though proportion of cover class I and II was maximum in PGLN (30.7% and 27.6% respectively) still it was observed that hog deer preferred class II and class III, whereas class I and class IV were used in proportion to their availability. In addition to this, the proportion of fresh sprouts and young shoots were relatively higher in PGLN. Hog deer preferred fresh sprouts in PGLN, SGLN and SGLP while young shoots were preferred only in PGLN. Since hog deer indicated preference for feeding on burnt areas in summer and PGLN had maximum proportion of burnt plots (34.9%) (Table 5.11.2), burning was another factor to have influenced the selection of this habitat type by hog deer. In natural grassland, incidence of fire occurred at different time intervals which resulted in formation of a mosaic of both burnt and unburnt patches, thus providing both cover and forage. Whereas in other areas especially PGLP the whole patch was burnt completely which resulted in sudden loss of resting cover though hiding cover was available near by. It was observed that burnt areas provided some cover in patches to the species because of the presence of burnt tussocks of well established grasses. Though proportion of matured grasses was maximum in summer but most of these matured grasses were

burnt through fires set by people. After burning hog deer became completely camouflaged and so blended with the burnt grassland and standing tussocks that at times it was not possible to spot an individual until it ran and the white under part of the tail was visible. In summer selection of PGLN was mainly governed by factors concerning with forage and cover. Since hog deer overall showed a preference for burnt areas in summer, it was observed that burnt areas in PGLN were preferred by hog deer. It could be concluded that burning in summer influenced the selection of natural grassland in summer.

### 6.3 Seasonal avoidance of habitats

RGL was found to be avoided by hog deer in both the seasons as indicated by the direct method whereas preferred by indirect method. Such variation in preference could either be a function of grass height which influences the visibility or difference in rates of pellet deposition between fawn, yearling, and adult deer or may be a result of its diet (Dhungel 1985). On analysing the habitat components in RGL it was found that in winter the overall availability of fresh sprouts in RGL was very low (13%) and their use was low. On the other hand though maximum proportion of grasses in winter were in young shoots still it was observed that hog deer avoided this phenophase in RGL. Whereas in winter hog deer was observed to prefer only matured grasses in RGL habitat. Hence though the preference of all these individual variables were very similar to overall preference of hog deer for winter but still its avoidance for RGL could be a function of uniformly high grass height or an effect of grass composition. On analysing the grass composition species wise it was observed that *Vetivaria zizinioides* (Kashia) one of the coarse grasses was found to be dominant (23.3%) (Fig 5.2.1). While proportion of thatch one of the grass species preferred by hog deer (Gara 1991) was only 16.8%. Though RGL (grassland all along the river Torsa) had dense cover and presence of water this habitat had minimum abundance. In RGL both in summer and winter the

average group size was small hence giving a clue to the presence of good cover in this habitat type. This is further confirmed by the average grass height and cover available at all three heights which was found to be maximum relative to all other habitat types (Table 5.2). The fact that hog deer is grazer and solitary animal makes it important that it selects a combination of highly nutritious food and good grass cover. Hence avoidance of this habitat type by Hog deer seems to be related to a low community diversity; species composition and their nutrient content related to structural stage. The results of indirect method indicated an opposite trend with high pellet group density. Gara (1993) had found maximum no. of sightings of hog deer in tall grasslands along the Rapti and Narayani rivers in Nepal. The other possible explanation for such variation in dung density and abundance maybe because hog deer used this habitat type for resting cover. This could be supported by some of the sightings I had in which the animals were found to move into the dense cover of *Vetiveria* when disturbed as a response to my presence. As the grass height was tall so it was not possible to see resting animals once they entered these areas unless opportunistically flushed, thus resulting in an overall low abundance. These are the same grassland which are called as "grass jungles" (Putman 1988) by lot of pioneer scientists working in terai grassland of South East Asia. Though direct sighting were very few the consistently high presence of pellet groups or dung density/ha in winter gave a clue to the presence of hog deer in this habitat type. Since pellets give a more reliable estimate of utilization of habitat though not for what purpose unless other evidences indicate a specific function. It could be presumed that since hog deer were rarely seen feeding in RGL they seemed to be using this narrow and linear habitat type as escape or resting cover.

RGL was found to be avoided by hog deer in summer by direct method whereas preferred by indirect method the results are unlikely to be a consequence of any sampling bias because in summer there was no significant difference in average grass height between habitat types. This can be further explained by the fact that in summer

most of the grasslands were subjected to fires so the difference in average grass height was nullified. Since the average difference in grass height across different habitat types was nullified, the visibility bias was also nullified. Thus a direct comparison of mean abundance/hr is relevant between RGL and other habitat types in summer. The overall availability of fresh sprouts and young shoots in summer was maximum in RGL (53.7% and 40.9% respectively). However the results of direct sighting show that hog deer avoided areas in RGL with fresh sprouts. Whereas areas with young shoots and matured grasses were used in proportion to their availability. Such a discrepancy in selection of phenophase by hog deer could only be explained by comparing pellet or diet quality and composition with habitat quality and composition. When grass composition was analysed in RGL it was found that *Vetivaria zizinooides* was most dominant since it was encountered in 26.02% of plots, whereas the forage species (*Imperata cylindrica*) known to be preferred by hog deer contributed only 18.8 % of the total availability.

The other major difference in results of habitat use lies between PGLP and SGLN. From direct method it appears that hog deer used PGLP in proportion to its availability in both the seasons whereas indirect method makes the pattern more distinct by showing preference for this habitat type in both the seasons. It was not possible to get a clear pattern of use of PGLP because the average grass height was quite tall and hence visibility might have created a bias since hog deer is a shy species and most of the time they used to take refuge in these grasses when disturbed. However the difference in grass height within a season was not significant between habitat types except for RGL. So the possible cause for such variation remains unexplained. However from the available information it appears that in winter in PGLP fresh sprouts were maximum in proportion (28%), followed by young shoots (13.4%) and very low matured grasses (3%). Though proportion of matured grass was less still it was found that hog deer in winter preferred this phenophase (Table 5.25) because it

provided good escape cover (Table 5.1) whereas avoided fresh sprouts. Avoidance of fresh sprouts could be because of high proportions of non palatable species (Table 5.2.1). This is also supported by the fact that hog deer showed a preference for grass height class II, III, and IV as escape cover in PGLP whereas avoidance for class I. Hence it appears that PGLP was preferred by hog deer because of the availability of escape cover classes. Since burning in PGLP resulted in complete loss of cover and the avoidance of such areas by hog deer in winter (Table 5.39) further strengthens the assumption that hog deer selected this habitat because of high grass height which provided good escape and resting cover to the species. Though most of the grasses in PGLP were in fresh sprouts still these areas were not preferred by hog deer. The possible reason for such a selection could be because, these areas were used as resting sites. Since this information was not quantified in the present study so it is difficult to give an explanation for such an unexpected trend with the present type of data. However in summer though indirect method showed preference but from the overall information on availability and utilization it appears to be avoided. In summer although the area was burnt hog deer didn't have any preference for burnt areas because proportion of both fresh sprouts and young shoots was found to be minimum in these grasslands (4.9% and 9.1% respectively). Burnt areas of PGLP were also found to be avoided by hog deer in summer. Since direct method showed a proportional use of these areas so it may be presumed that since fresh sprouts and young shoots were low and burnt areas avoided so the overall use in summer may be low, but contradictory to this indirect method showed a preference for these areas. Such a contradiction in results were obtained because in summer the second dung count in PGLP was unexpectedly got delayed by 15 days and there were frequent rains between this time period which might have influenced pellet counts.

From direct sighting hog deer showed an overall preference for SGLN but at seasonal level these areas were found to be used in proportion. However from indirect

method it was found that hog deer avoided SGLN in both the seasons. In this case the results of indirect method indicated a more distinct and clear pattern of utilization because the proportion of different habitat variables (fresh sprouts, young shoots and matured grasses) were relatively less. It was also found that these grasslands were dominated by *Mikania scandens*. Though at times mikania was observed to be used as cover but there were hardly any observation where hog deer was found to feed on them. Since availability of foraging grass was less so hog deer was observed to avoid these areas. However the preference for fresh sprouts in this area along with preference for escape cover of class II explains the use of this habitat type as a resting ground.

On comparing the effect of cut and uncut grass on use of habitat by hog deer it was found that pellet group density/ha differed between cut and uncut areas. Mean dung density in cut area was found to be more than in uncut area. Such a difference in mean pellet group density between cut and uncut area is possibly because cutting enhances the growth of grasses and hence availability of more fresh sprouts to hog deer.

#### **6.5 Extent of use of preferred habitats of hog deer by other sympatric species**

The pellet group count technique has long been used in wildlife studies for a variety of purpose (Putman 1984). In this study, the monitoring of line transects yielded sufficient data only for hog deer for estimating the seasonal use of different habitat and habitat variables. Whereas for chital and rhino only overall comparison or overall information on habitat use from dung density could be estimated. No seasonal pattern could be obtained because in case of chital in winter pellet groups were encountered only in SGLP and in case of rhino, dung piles in summer were encountered only in RGL. It also should be noted that results of dung count cannot be used to compare habitat use between species specially with rhino since they are primitive animals and their ecology and physiology is remarkably different from hog deer, chital and cattle and

the dung deposition is not random. However the results of pellet group counts can be used to compare the habitat use between of hog deer and chital. In spite of the significant difference in mean pellet group density of four species across habitat type I didn't quantify the predicting variables for rhino, chital and cattle since they are generalist i.e., subsisting on a mixed diet of grass and browse and adapted to a variety of topography and vegetation types. In such a situation it is highly unlikely that their distribution will be strongly influenced by few habitat variable as may be the case with hog deer which inhabits grasslands only. From direct method the overall mean abundance/hr of hog deer in different habitats were compared with the overall mean abundance of chital and rhino. It gave an overall idea about the extent of use of preferred habitats of hog deer by other sympatric species. Whereas from indirect methods occurrence of cattle was also compared in addition to chital and rhino.

Chital was found to have maximum abundance in SGLN in both the seasons. In winter chital was found to prefer SGLN whereas in summer none of the habitats were preferred. PGLP, SGLN and SGLP were used in proportion to their availability. Since chital is more generalist than hog deer (Tak and Lamba 1981, Sankar 1991, Mishra 1982) they were found mostly associated with SGLN and rarely with natural or pure grassland. Chital is an introduced species in Jaldapara so the population is very low and so was the data on abundance. However their preference of SGLN suggests some interaction with hog deer. Though chital at many places are found to have influenced the habitat use of other species (Mishra 1982; Negi (Deputy Director, Kanha Tiger Reserve) *pers comm.*; Tak and Lamba 1981, Raman 1996) but at Jaldapara the situation is insignificant at this stage. From dung counts PGLN was found to be avoided by chital and SGLP was found to be preferred. Both results are depicting the natural ecology of chital. At the same time it also gives an idea of the level of interaction between these species. Hog deer was found to prefer PGLN whereas chital was found to avoid these grasslands. Both hog deer and chital were found to avoid RGL. Proper monitoring to

ascertain use of these habitat type by both the species over longer time may give some interesting results:

Rhinoceros on the other hand was found to prefer PGLP and avoid PGLN. This result is quite contradictory to the general ecology of rhino (Laurie 1978, Dinerstein and Price 1991, Ghosh 1991). But this situation is true for Jaldapara since here stretches of natural grasslands occur in very small extent. Plantation grasslands on the other hand are specially managed with a view to conserve this species. In these areas plantation of fodder species is done and grasslands are maintained. Indirect methods also showed a similar result with preference for PGLP and avoidance for PGLN. In order to increase the area under grassland vegetation and to increase the forage production a total of 664 ha was brought under fodder plantation in JWLS (Pandit 1996). Although some plantations have succeeded, the overall success is less than 10% and in terms of there utilization it is seen that these areas are preferred only by rhino. Though hog deer are also found to use these areas but the overall use is negligible as compared to natural grasslands.

Hog deer use of habitat was found to overlap considerably with cattle use because both these were found to prefer PGLN. Since PGLN is located very close to villages this habitat type is more exposed to anthropogenic pressures.

## **6.6 Encroachment of grasslands by weeds and woody species**

Fodder plantation areas cannot be excluded from grazing by guar and elephant. Heavy use of plantation areas by these species is most likely to encourage growth of less palatable exotic weeds such as *Ageratum conyzoides*, *Eupatorium odoratum*, *Mikania scadens*, etc., which suppress regeneration of native species. On comparing weed density in each habitat type it was observed that weed encroachment was maximum in SGLP. This explains the poor use of this habitat by wild ungulates. The overall abundance of weed is maximum in all the habitat types except for RGL were it

was extremely low. Weeds are not able to colonise this habitat because this is the most unstable habitat and prone to annual flooding which does not allow weeds to grow. Due to lack of proper maintenance of plantation areas and subsequent digging by wild pigs, growth of certain opportunistic herbs rather than grasses are favoured.

Woodland encroachment was found to be maximum in SGLN as reflected by the maximum recruitment density, though tree density was higher in the plantations of grasses of fodder value, raised after felling some trees. Removal of woody vegetation from well established natural forest and plantation of few fodder grasses have lead into reduction in diversity of forage species and invasion by weeds.

Where as on the other hand regeneration was maximum in PGLN as reflected by the maximum seedling density /ha. Sapling density was also maximum in these areas. Hence PGLN are under the maximum possibility of woodland transformation after SGLN.

## **6.7 Disturbance**

Results of disturbance show that overall disturbance in terms of fire and grass cutting was maximum in natural grassland (PGLN) which is the preferred habitat by hog deer. The only possible reason for such high interference is its location. The stretch of natural grassland lies in the older course of Torsa and is very close to the villages. Except for one or two situation in most of the other cases cattle were found to be grazing in this habitat type. Easy accessibility, good location and availability of foraging grasses and water seems to be the most important factor attracting both wild and domestic ungulates along with grass cutters. But high abundance of both cattle and hog deer in this tract of natural grasslands doesn't mean that cattle grazing should be allowed in this area because apart from direct competition for forage cattle acts as the most important source for transmission of diseases, increasing compactness of soil by regular trampling.

Grass cutting on the other hand puts these grasslands under severe stress since people enter in large groups causing an overall disturbance to the sanctity of the forest. Grass cutting was also found to be high in natural grassland along with plantation grassland. The reason being the collection of thatch by local people as housing material and also for marketing. Infact an interesting trend was found on comparing pellet density of hog deer in cut and uncut areas. It was observed that pellet group density of hog deer was higher in cut areas as compared to uncut areas because cutting enhances grass growth thus forage for hog deer thus explaining the high abundance of hog deer in natural grassland as compared to other habitat types. Cutting was overall found to be relatively less in other habitat types because of good protection done by the patrolling staff and inaccessibility in terms of logistic and danger in those areas.

## Chapter 7

### Conclusions & Management Recommendations

#### 7.1 Conclusions

##### 1. Habitat use

- Hog deer preferred areas with fresh sprouts and extensive grass cover as opposed to low cover areas. Thus preferred natural grassland.
- Hog deer avoided areas with low forage and high weed abundance. Thus avoided savanna grassland plantation

##### 2. Factors influencing habitat selection

- Maximum abundance of hog deer were found in areas with higher proportion of *Imperata cylindrica*.
- Fire or burning of grasslands in combination with rain or presence of water seems to influence the overall selection of habitat by hog deer.
- In winter fresh sprouts and water and in summer cover and fire influenced the habitat selection.

Thus availability and quality of food, water and antipredator strategy of hog deer are important determinants of its habitat selection.

### 3. Extent of overlap with other sympatric species

- Cattle has maximum influence on the habitat use of hog deer since they both prefer natural grasslands.
- Rhino doesn't seem to directly facilitate the habitat use by hog deer since areas preferred by hog deer are avoided by rhino.
- At present chital doesn't have much interaction with hog deer since they prefer savanna grasslands which are avoided by hog deer.

### 4. Disturbance and Habitat Degradation

- Level of disturbance in terms of cutting, Burning and cattle grazing was found to be maximum in natural grasslands.
- SGLP and SGLN are found to be most degraded in terms of high weed density and woodland encroachment. And natural grasslands were found to have maximum potential to transform into a woodland because of high regeneration.

Thus , it is the stretch of natural grassland which has maximum influence on habitat utilization pattern of hog deer. But on the other hand it has maximum level of disturbance because of various reasons. It is also among one of the potential areas to get converted into woodland. The results of this study could highlight the importance of natural grasslands for hog deer.

## 7.2 Management recommendations

### *Single species conservation*

Jaldapara Wildlife sanctuary along with Gorumara WLS are the only areas in West Bengal with population of rhino which were historically distributed over a much larger geographic extent. The population underwent bottlenecking and has shown positive indications of recovery in recent past. This has been made possible due to dedicated conservation-management undertaken by the West Bengal Forest Department. Strong anti poaching measures were adopted by the management along with single species habitat management strategy. A featured species approach is not new to modern day wildlife management, which in addition considers a host of other species as well (Thomas 1979). However, this approach has not been followed in totality and has resulted in giving full attention to only rhino in matters of habitat management. This has led to opening up woodlands which has brought in weed invasion; raising plantations of tall grasses that have reduced diversity for other ungulates; annual burning that may have already set a trend of change in vegetation communities, not necessarily favourable. A comparative map (plate 4.2) of the area 10 years back gives an indication of the grassland area lost due to various reasons. In order to make good that loss, a strategy of planting fodder species favoured by rhino was undertaken. In doing so many areas were cleared for plantations irrespective of their historical background and ecological status. In other words it is a strategy to maintain habitats in early succession stages especially the grass-forb stage. Some of the previous savanna areas were also converted to plantations. Though rhino were found to favour the plantation areas other species such as hog deer and chital seem to avoid such areas. Such orientation is explained by the homogenous composition and coarse quality of the grasses. In case of

hog deer it was observed that they used this area only for cover in winter. In summer these areas were avoided because of dramatic loss of escape cover due to burning. Since hog deer is a grassland dwelling species and with evidence that structural mosaic and diversity of grass species in early phenophase are selected by hog deer, structurally uniform and composition wise low diversity, plantations are most likely to adversely affect the hog deer and chital population.

Rhinos on the other hand also do not seem to directly facilitate the habitat use by hog deer since areas preferred by hog deer are avoided by rhino. The habitat use of rhino in JWLS seems very different from its orientation in large natural grasslands elsewhere in terai, where tall grasslands with structural mosaic of a variety of grass species with temporal use of woodlands. In JWLS, the area is small and the rhino is adapted to artificially maintained grasslands which might run the risk of proving unsustainable over the long run. There needs to be some focussed monitoring of habitat use by rhino to understand seasonal requirements of other herbivores. Removal of over wood seems to bring in vigorous growth of weeds which is not helpful.

### ***Burning***

Burning is seen to influence the use of habitat by hog deer so it needs to be properly designed. Fire results in loss of escape cover, increase of fresh sprouts and at times also seems to change the moisture condition and species composition of an areas with time. In case of natural grasslands the grass community is more heterogeneous by structure and composition with availability of different phenophases within a certain time span. This provides favourable habitat conditions supportive of food and cover requirements. Whereas the situation is exactly opposite in Plantation grassland. Burning is a very common phenomena in the PA. What started as a prescribed burning strategy

has now changed to people generated fires that are not designed to achieve specific objectives as they are random and repetitive and management has hardly any control over it given the unusual shape of the PA. Since burning is supposed to favour growth of grasses and hence selection of habitat, it is yet necessary to look at it critically because it can both improve when applied by design and reduce the habitat quality if not designed properly. Since mostly fires in Jaldapara are man-induced/accidental there is little scope for planning it properly in a small area as people set fires randomly, especially in plantations. However in natural grasslands the structure of grassland is such that it creates a mosaic of burnt and unburned patches which is favoured by hog deer. Water management done within this stretch of grassland also has influenced the habitat use.

#### ***Monitoring chital –hog deer interaction***

Though at present the habitat use appears to be different but in long run chital may have some influence on the habitat of hog deer with a build up in its population. At present chital doesn't seem to have much interaction with hog deer since they prefer Savanna grassland (natural) and hog deer are observed to be avoiding avoided savanna grasslands.

#### ***Protection to natural grasslands***

This is a favoured habitat of the hog deer and prone to highest incidence of cattle grazing and grass cutting. Pure grassland though preferred by hog deer was also found to be preferred by cattle because these areas are close to villages and eminently suitable for cattle grazing. Though disturbance was also found to be high in this area in terms of grass cutting it had a positive effect on hog deer since they were found to select for these areas. Though hog deer preferred cut areas, it doesn't mean that unrestricted cutting should be allowed. This is because although cutting has a positive effect on the

forage phenology the impact of group of people entering the park to cut grasses may further increase possibility of degradation. This needs a concerted effort to reduce cattle grazing substantially. The risk of spread of infectious diseases through cattle among wild ungulates must be regarded as very high all times.

### ***Weed removal***

Areas with weeds are avoided by hog deer as weed reduces the habitat quality, plantations in these areas fail. Manual removal of weeds is not a practical proposition. Sudden removal of overwood, fires and cattle grazing are factors that favour weed abundance. Unless these are controlled, any further attempts by other means to control weeds is not likely to succeed. Savanna grassland (plantations) are avoided by hog deer in both the seasons since it's highly infested with weeds with very poor percentage of grasses and forbs. However this type provided a good escape cover since it is present adjoining to grassland areas, used by hog deer.

Riverine grassland area needs to be protected as it is linear in shape and thus most vulnerable to change. This type has indicated high value as resting cover for hog deer.

### **Further Study**

The current study of barely six months is inadequate to understand hog deer ecology. It is evident that floodplain grasslands are being rapidly lost or altered to a variety of land use pattern and logic suggests that a grassland dependent species like the hog deer stands in grave danger of losing populations locally which would put its status and existence in jeopardy. Though this study could identify some of the important factors governing its habitat selection but doesn't answer all the questions about the ecology of a species. This study thus advocates the need of a long term study on hog deer to support its conservation strategies.

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APPENDIX I

LIST OF GRASSES AND FORBES, HERBS AND TREES ENCOUNTERED WITHIN MY INTENSIVE STUDY AREA AT JALDAPARA WILDLIFE SANCTUARY, 1999

SCIENTIFIC NAME	LOCAL NAME	LIFE FORMS	REMARK
<i>Allium spp.</i>	Lashune	-	
<i>Wrightia arborea</i>	-	-	
<i>Mikania scandens</i>	Mikania	C	W
<i>Natsiatum herpeticum</i>	Gulthai	C	
<i>Antidesma acidum</i>	-	G	
<i>Apluda mutica</i>	Choto Chepti	G	
<i>Arundinella benghalense</i>	Jhadu	G	
<i>Arundo donax</i>	Nol	G	
<i>Axonopus compressus</i>	-	G	
<i>Bryphyllum calycinum</i>	-	G	
<i>Chloris spp.</i>	Dubba	G	
<i>Chrysopogon aciculatus</i>	Chorkata	G	
<i>Cymbopogon jawarancusa</i>	Lemon Grass	G	
<i>Cymbopogon flexuosus</i>	Gandhoali	G	
<i>Cynodon arcuatus</i>	-	G	
<i>Cyperus eleusinoides</i>	Kella	G	
<i>Cyperus niveus</i>	Chechura	G	
<i>Digitaria albudens</i>	Bodo Chepti	G	
<i>Elusine indica</i>	Kanchulka	G	
<i>Equistem spp.</i>	Hatujora	G	
<i>Eragastis spp</i>	Bhunshi Ghans	G	
<i>Eragrostis gangetica</i>	Envoali	G	
<i>Eriantus longisetosus</i>	Dhadda Chepti	G	
<i>Fimbristylis acuminata</i>	-	G	
<i>Fimbristylis dichotoma</i>	Bodo Chechura	G	
<i>Imperata cylindrica</i>	Thatch	G	
<i>Paspalum flavidum</i>	-	G	
<i>Paspalum paspaloides</i>	Moina Ghans	G	
<i>Phragmites karka</i>	Khagri	G	
<i>Saccharum arundinaceum</i>	Dhadda	G	
<i>Saccharum bengalense</i>		G	
<i>Saccharum narenga</i>	Malsha	G	
<i>Saccharum spontaneum</i>	Ekhra	G	
<i>Setaria paniculifera</i>	Bash Pata	G	
<i>Setaria glauca</i>	Fox Tail	G	
<i>Sporobolus diandra</i>	Bidna	G	
<i>Typha spp.</i>	Hogla	G	
<i>Vetiveria zizinoideis</i>	Kashia	G	
<i>Achyranthas aspera</i>	Boal Kata	H	W
<i>Ageratum conisoides</i>	Bhurbhushi	H	W
<i>Chromoilina odornata</i>	Assamia Lata	H	
<i>Desmodium latifolium</i>	-	H	

G = Grass, W = Weed, T = Tree, H = Herb, S = Shrub

Continued.....

SCIENTIFIC NAME	LOCAL NAME	LIFE FORMS	REMARK
<i>Hyptis suaveolens</i>	Pon Tulshi	H	W
<i>Mimosa pudica</i>	ana Bat:	H	
<i>Peristrophe bicalyculata</i>	-	H	
<i>Phyllanthus niru</i>	Kata Sirish	H	
<i>Pogostemon spp</i>	-	H	
<i>Tylophora indica</i>	Dudhali	H	
<i>Urena lobata</i>	Chokhra	H	
<i>Acacia catechu</i>	Khair	S	
<i>Cayratia pedata</i>	-	S	
<i>Cherodendron viscosum</i>	Bhanti	S	W
<i>Glochidion velutinum</i>	-	S	
<i>Lantana camara</i>	Lantana	S	W
<i>Randia longispina</i>	Moinakata	S	
<i>Tabernaemontana divaricata</i>	Tagar	S	
<i>Albizia procera</i>	Sirish	T	
<i>Bombax ceiba</i>	Simul	T	
<i>Butea monosperma</i>	Pallash	T	
<i>Callicarpa macrophylla</i>	Khoksha	T	
<i>Casearia graveolens</i>	-	T	
<i>Cedrela toona</i>	Toon	T	
<i>Cordia dichotoma</i>	Bahol	T	
<i>Dalbergia sissoo</i>	Sissoo	T	
<i>Dillenia pentagyna</i>	Tartari	T	
<i>Duabanga grandiflora</i>	Lampate	T	
<i>Ehretia acuminata</i>	Katgua	T	
<i>Ficus spp.</i>	-	T	
<i>Ficus cuneifolia</i>	Kuchli	T	
<i>Gmelina arborea</i>	Gamari	T	
<i>Grewia tilliaefolia</i>	Phersa	T	
<i>Lagerstomia parviflora</i>	Sidha	T	
<i>Litsea monopetala</i>	Daton	T	
<i>Macaranga denticulata</i>	Malata	T	
<i>Mallotus philippensis</i>	Sindure	T	
<i>Melia azadirachta</i>	Wild Neem	T	
<i>Oroxylum indicum</i>	Surimara	T	
<i>Phyllanthus emblica</i>	Amla	T	
<i>Premna bengalensis</i>	Dhau	T	
<i>Premna mucronata</i>	Gineri	T	
<i>Streblus asper</i>	Seora	T	
<i>Syzygium spp.</i>	Jamun	T	
<i>Tamarix dioica</i>	Jhau	T	
<i>Terminalia bellerica</i>	Hartuki	T	
<i>Terminalia chebula</i>	Pitali	T	
<i>Trema orientalis</i>	Jigni	T	

G = Grass , W = Weed, T= Tree, H = Herb, S = Shrub

N.B. Plant specimens and trees were identified with the help of herbarium at W.I.I., Cowan & Cowan ( 1929 ) in Pandit (1996).