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HABITAT SELECTION BY INDIAN PEAFOWL (Pavo cristatus Linn) IN GIR FOREST, INDIA

DISSERTATION SUBMITTED TO SAURASHTRA UNIVERSITY, RAJKOT, IN PARTIAL FULFILMENT OF MASTER'S DEGREE IN WILDLIFE SCIENCE (1993)

BY

PRANAV TRIVEDI

SUPERVISED BY:

Dr. A.J.T. JOHNSINGH: HEAD, FACULTY OF WILDLIFE BIOLOGY,

WILDLIFE INSTITUTE OF INDIA, DEHRADUN.

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भारतीय वन्यजीव संस्थान
Wildlife Institute of India

CERTIFICATE

This is to certify that Mr. Pranav Trivedi of the Wildlife Institute of India has carried out an original piece of research work entitled "Habitat selection by Indian peafowl (*Pavo cristatus* Linn) in Gir Forest, India" in partial fulfilment of M.Sc. (Wildlife Science) degree of Saurashtra University. These investigations were carried out under my supervision at the Wildlife Institute of India from November 1992 to June 1993. I also certify that this work has not been submitted for any other degree of any university.

DATE: 4/7/93.

PLACE: DEHRADUN

A.J.T. Johnsingh

A.J.T. JOHNSINGH

HEAD, FACULTY OF WILDLIFE BIOLOGY

Post Box No. 18, Chandrabani, Dehradun-248 001. India
EPABX: 82912 to 82915. Fax: 0135-82217. Telex: 585/271 WII IN Gram: WILDLIFE

SUMMARY

A study on habitat selection by Indian peafowl (*Pavo cristatus*) was carried out in Gir National Park and Sanctuary over a period of five months. Open width line transects were laid at three study sites in West, Central and East Gir respectively to obtain information on availability and use of habitats. Three hundred and thirty sightings were obtained in 90 transect walks (totalling to ca 113 km), of which two hundred and fifty occurred in West, and forty each in Central and East Gir. As sampling intensity was the highest in Saşan (West Gir), much of the analyses is based on the data collected here.

Thirteen plant communities were identified. These were: riparian forest (RIP), teak mixed forest (TMF), teak mixed forest-Hill (TMF-H), teak-*Acacia* community (TA), degraded forest (DF), pure teak woodland (PTW), thorn Woodland (TW), savanna (SAV), scrubland (SCR), *Lannea-Boswellia* community (LB), cultivation (CULT), *Anogeissus-Acacia* community (AA) and *Anogeissus* mixed forest (AMF). Of these, ten occurred in West, six in Central and four in East Gir. Major qualitative and quantitative features of these have been discussed.

Peafowl distribution was found to be clumped, with the degree and site of clumping being affected by water and food availability. RIP, CULT and DF were used more than their availability; TW, SAV and SCR were used in proportion and TMF and TA were used less than availability. TMF(H) and LB were null habitats with no sightings in these habitats in Sasan.

Water, food and predator avoidance coupled with structural features of the landscape seem to be exerting profound influence on habitat selection by peafowl in Gir. In general, open areas in the vicinity of water were used more. Low tree density (<100) and low grass and herb height (<15 cm) were used more, whereas high tree density (>700) and tall grass were used less than availability. All shrub density categories were used in proportion to availability. There was no marked seasonal difference in habitat use. Sexes did not differ significantly in their habitat choice. There was a pronounced difference between group size in different habitats. Exceptionally large group sizes were encountered in resource-rich (e.g. RIP) as well as open habitats. It is believed

that grouping in open areas is an antipredatory strategy.

Twenty one species of trees were used as roosts. Roosts were mainly confined to RIP. Tall trees on steep river banks with climber thickets in the canopy and/or thorny undergrowth thickets were selected, which is an antipredatory strategy against mammalian predators. Use of *Holoptelia integrifolia* and *Pongamia pinnata* as roost trees was more than their availability , whereas *Tamarindus indicus* was used less than availability and the rest used according to availability. Roost tree selection may be a hierarchial process with structure at,a broad and floristics at a finer scale acting as cues.

ACKNOWLEDGEMENTS

Many individuals and institutions have made this project a reality and I wish to express my gratitude to all of them. Two individuals have been instrumental in my active involvement in the field of wildlife - Rajesh Shah and Vaibhav Garde and I owe a lot to them. My admission to the Wildlife Institute of India was possible due to the guidance provided by Karmavir Bhatt.

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I must thank Wildlife Institute of India where I received the required institutional support and an intellectual atmosphere. Help from IUCN in the form of a fellowship during the course of study is kindly acknowledged.

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CHAPTER 1: INTRODUCTION

Habitat selection is defined as the choice of one (or more) habitat(s) from the available habitat types. Habitat selection theory is a branch of optimal foraging theory (Rosenzweig 1985), where the habitats are viewed as patches. Optimum patches which maximise reproductive success (within the given constraints) are selected by the animals.

The concepts of habitat selection have occupied a central place in behavioural ecology for many decades (Cody 1985). Excellent opportunities to study habitat selection are provided by birds as they are mostly diurnal, highly mobile, wide ranging, and relatively easy to observe (Cody 1985). Habitat selection of any species is a result of prevailing environmental conditions and constraints in evolutionary terms. Apart from its significance in systematics, competition theory and the concept of niche, the knowledge of this aspect carries immense importance for planning conservation of species and maintaining diversity of ecosystems. Studies on habitat selection provide baseline data for evaluating the impacts of human action on the species and are very useful for monitoring the status of the species.

Habitat selection is a dynamic process as the natural systems are also dynamic (Wiens 1985). Various factors such as morphology, behaviour, ability to obtain food and shelter (ultimate factors), and structural features of the landscape, foraging or nesting opportunities, or competition (proximate factors) influence habitat selection in birds (Hilden 1965 in Cody 1985). These factors may act independently or synergistically in a complex manner. Both, physical structure and floristics of a plant community (i.e.

selection in birds (Hilden 1965 in Cody 1985). These factors may act independently or synergistically in a complex manner. Both, physical structure and floristics of a plant community (i.e. habitat) are believed to be responsible as specific cues for habitat selection by a species. Many species of birds are confined to very specific habitat types (Winkler & Leisler 1985), but some are versatile probably due to their greater plasticity in food and habitat choice, and lack of competitors.

Indian peafowl (*Pavo cristatus*) is a widely distributed bird in India [from Indus in the West to Assam in the East and from foothills of Himalayas (upto 2000 m.) in the North to Kerala in the South (Ali & Ripley 1987)]. It is a terrestrial, omnivorous (Ali & Ripley 1987; Johnsingh & Murali 1980), and large bodied bird of family Pheasianidae and is the national bird of India. Though fairly common in many areas of its distributional range, studies on wild populations of peafowl are scanty in India. Most of the existing studies were carried out either near human habitation or on captive/introduced populations. Therefore this study was planned to investigate habitat selection by Indian peafowl in Gir Natioal Park and Sanctuary. Data was collected for approximately five months (December 1992 to April 1993). This study has identified the factors influencing habitat selction by peafowl and draws tentative conclusions regarding the choice of habitat by peafowl.

1.1 REVIEW OF LITERATURE:

1.1.1 HABITAT SELECTION - As stated earlier, avian habitat selection along with its evolutionary and ecological implications has a long history in literature (Cody 1985), starting from Charles Darwin's time to date. The thrust in most of the studies has been on explaining patterns of diversity and community, or depicting the role of environmental factors in determining the observed pattern of habitat selection, with some studies also addressing questions relating to the actual mechanism involved in the process of habitat selection.

Lack (1933) showed differences in habitat selection by birds, during plant succession in a pine plantation. He also showed that some birds were quite flexible in their preference and that the preference of a species may vary in two different regions, which was later confirmed by Wiens (1985). Svardson (1949) stressed the role of competition in habitat selection showing that intraspecific population pressure tended to broaden habitat use, while interspecific competition tended to limit it. As stated earlier, Hilden (1965 in Cody 1985) distinguished and summarised the ultimate and proximate factors involved in habitat selection by birds. Klopfer (1963 in Cody 1985) highlighted the role of early experience in habitat selection. Partridge (1978) who experimented on habitat selection in Coal and Blue tits, demonstrated the role of innate and learned behaviour in habitat selection. Morphological aspects such as body size, leg length, bill size, moulting, sexual dimorphism, and structure of the toes greatly influence habitat selection (Winkler & Leisler 1985).

Physical structure of the habitat (landscape features) has been shown to be an important cue for habitat selection (Cody 1981; Roth 1980; Terborgh 1985 and Wiens 1969 in Wiens 1985). Others, however have depicted the role of floristics as a more important feature of the habitat (Collins 1983; Holmes & Robinson 1981; Wiens & Rotenberry 1981). Habitat selection in bird communities has also been studied extensively (e.g. Burger 1985; Cody 1985; Terborgh 1985; Wiens 1985). Rice *et al.* (1983) have demonstrated remarkable seasonal shifts in the habitat selection by a riverine bird community showing the dynamic nature of habitats. Thus, exhaustive literature exists on avian habitat selection and the factors influencing it. However, in India only a few studies have paid attention to this aspect and even these have concentrated on avian communities rather than individual species (e.g. Daniels 1989; Katti 1990; MacDonald & Henderson 1977; Rai 1991).

1.1.2 PEAFOWL - Despite it being quite common (and locally abundant at places) throughout its range (Ali & Ripley 1987), the literature on peafowl in India is scanty. The few existing studies have largely provided information on natural history (Ali & Ripley 1987), general ecology (Johnsingh & Murali 1980), and morphometry (Dela'cour 1977 in Johnsgard 1986).

Sharma (1972) studied the breeding ecology and showed that breeding season is from June to August, modal clutch size was six, incubation period was twenty eight days, and hatching success was sixty four percent. Both, Johnsingh & Murali (1980) and Sharma

(1972) reported heavy post-hatching mortality. Johnsingh & Murali (1980) gave an estimate of density as nearly one bird/hectare. Though, Johnsgard (1986) claimed that the mating system in peafowl is harem defence polygyny, Hillgarth (1984), Rands *et.al.* (1984) and Ridley *et.al.* (1984) from their studies on the social organization and mating system (the latter two were carried out on introduced populations in the U.K.) showed that the mating system is promiscuous, the males displaying on 'exploded leks'. They further stated that the females mate selectively and location of male's territory, display sites, and skill of display may determine the mating success in addition to the quality of the train. Later, Manning (1986) provided the age-dependency model of female choice, suggesting that peacock's train is age-dependent in its length, size of ocelli, and colour intensity and selection by the female may depend on these features. As far as the affinities of this species are concerned, there is evidence to show that the genera *Pavo* and *Afropavo* (Congo Peafowl) are near relatives and both have some resemblance with guineafowl, but not with other Galliformes (De Boer & Van Bocxstacle 1981).

1.2 OBJECTIVES:

The major objectives of the study were:

1. To identify the role of various ultimate and proximate factors in determining habitat selection.
2. To look at seasonal variation and sex and age differences in habitat use. Also, obtain information on the variation in group

sizes between the habitats.

3. Relate these findings with reference to the evolutionary and ecological background of the species.

1.3 HYPOTHESES:

For achieving the above mentioned objectives, the following hypotheses were tested with the help of the data collected in the field:

1. As Sanctuary and N.P. vary in the degree of human interference and management practices (resulting in difference between the habitats present here), a difference in the densities between these two areas is expected. Also, as habitats vary in the structure, floristics and resource availability, the intensity of use will differ between the habitat types.

2. Due to dynamic nature of the habitats, a seasonal change in habitat selection will result.

3. Due to pronounced sexual dimorphism, specific behavioural repertoire, and social organization, the sexes will tend to differ in their habitat selection.

4. Group size differences between the habitats are expected due to variation in the structure and resource abundance of these habitats.

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CHAPTER 2: STUDY AREA

2.1 HISTORY - Gir forest, almost synonymous with Gir N.P. and Sanctuary was my study area. It is the only large, contiguous forested area in the Saurashtra peninsula of Gujarat in Western India. It is the single largest catchment of Saurashtra and therefore vital for the hydrology of this region. Previously this forest used to be extensive (about 3,100 km^2, Joshi 1972), but now only ca. 1500 km^2 of forest remains due to excessive clearance of land for agriculture, wood cutting, overgrazing and associated anthropogenic pressures. Though, a small part of it received protection from 1920 by the Nawab of Junagadh, it was only in 1965 that it was raised to the status of a sanctuary.

2.2 AREA AND LOCATION - Gir N.P. and Sanctuary (together referred to it as Gir Protected Area [PA]) extends over 1412.13 km^2, of which the N.P. is 258.71 km^2 and Sanctuary 1154.42 km^2. The PA lies almost on the Tropic of cancer i.e. 21° 20' to 20° 40' North and 70° 30' to 71° 15' East. It is about 40 km North from the Arabian Seacoast. The PA reaches 80 km in its West-East axis, while North-South it is 16-24 km except the tapering boundaries in the West and East (Khan *et al.* 1990; also see fig-1).

2.3 ABIOTIC COMPONENTS:

2.3.1 TOPOGRAPHY, GEOLOGY AND DRAINAGE - Gir region is hilly and undulating interspersed with broad and narrow valleys. The altitude ranges from 152 m to 648 m asl. In general, central portion (i.e. mostly covering N.P.) is more rugged and hilly, East is gently undulating to hilly and West is interspersed with broad

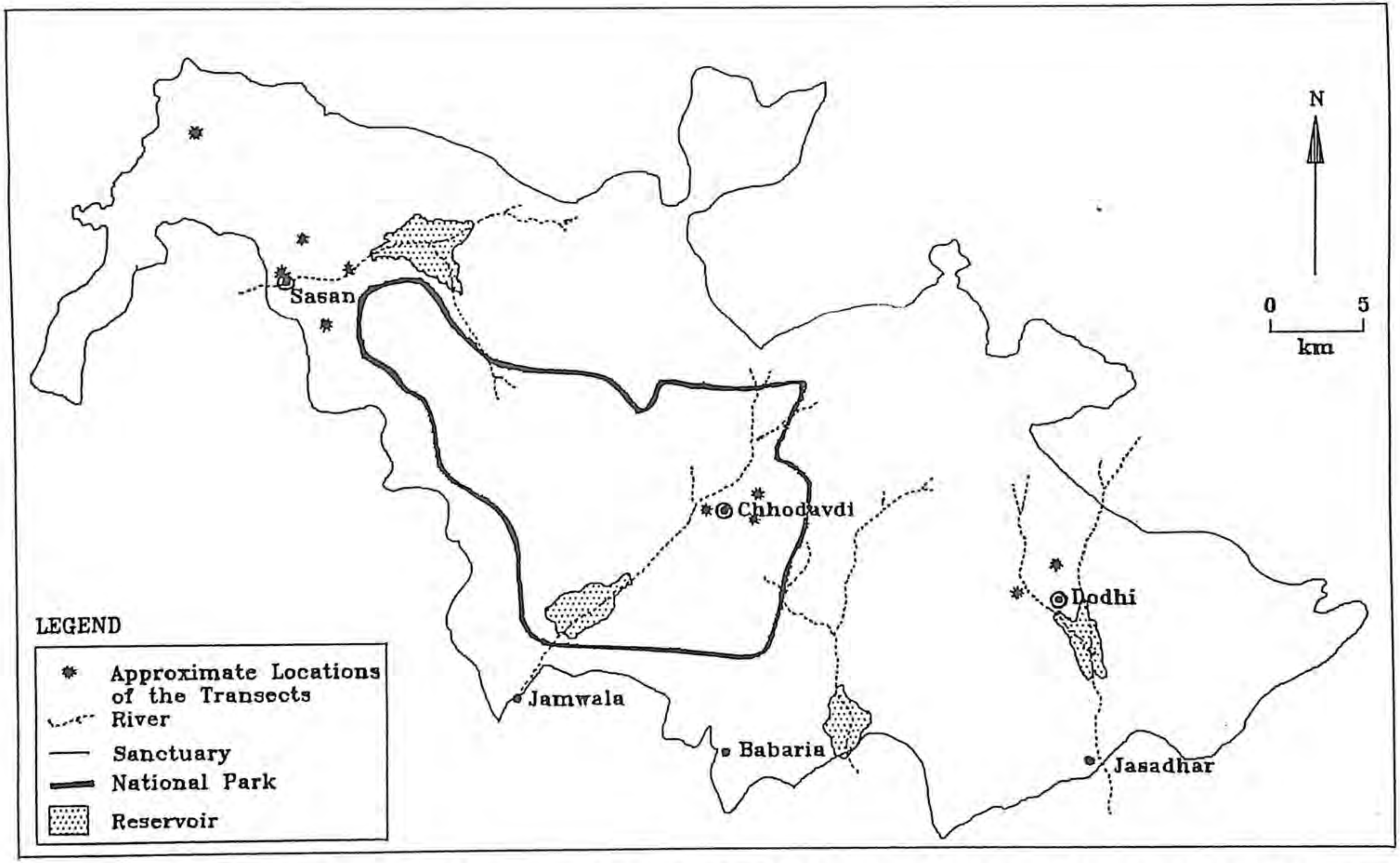


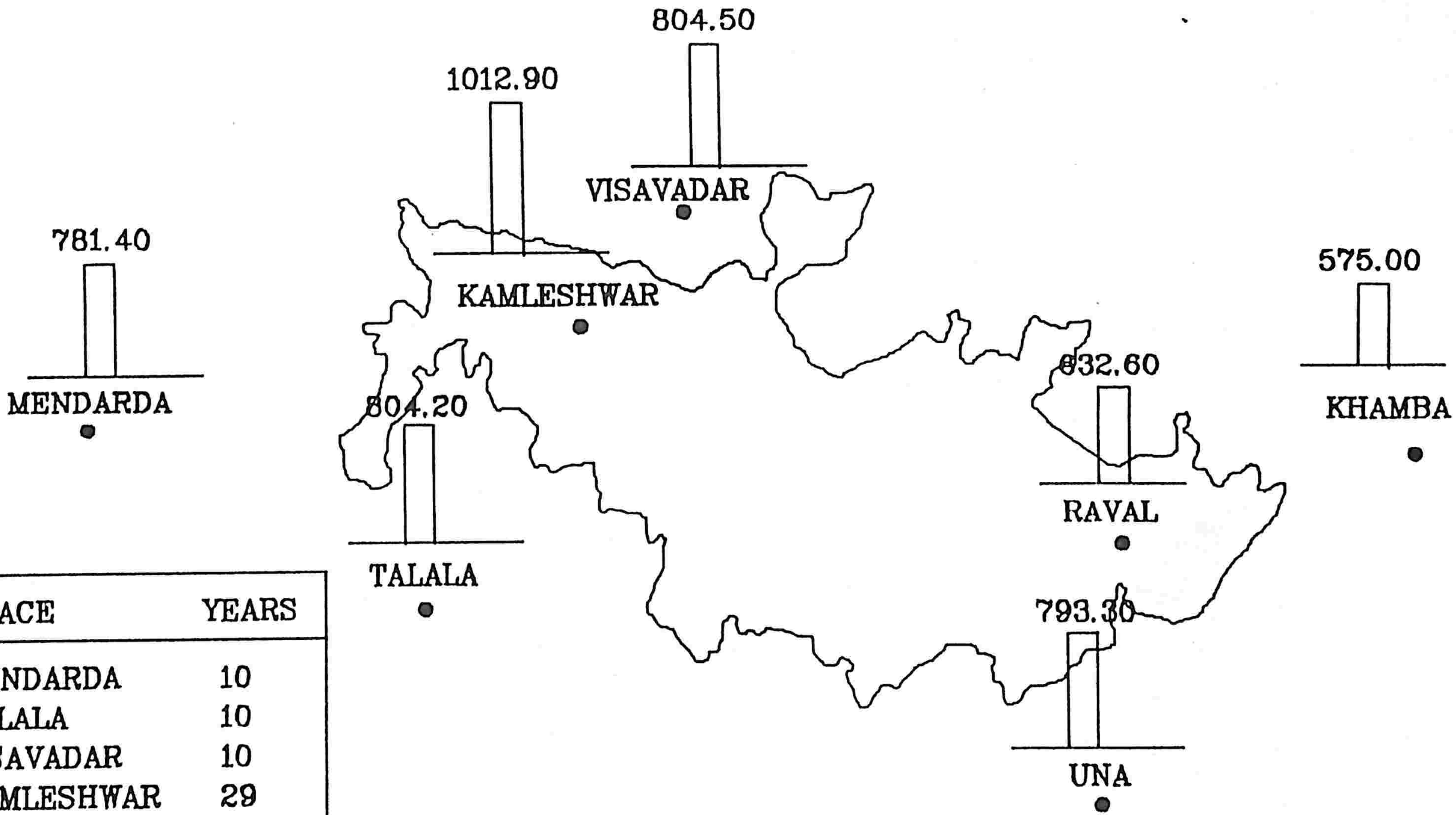
Fig.1 LOCATIONS OF INTENSIVE STUDY SITES AND TRANSECTS IN THE GIR NATIONAL PARK AND SANCTUARY

valleys and high hills. Geologically this region is a part of the Deccan trap (Basalt) formations of varying composition associated with granite and gneiss, overlain by beds of calcareous sandstones which in parts assume the nature of limestones (Santapau & Raizada 1956). The major soil types are black-cotton, red and alluvial (sandy).

The PA is drained by at least eight rivers (Hiran, Popatadi, Jatadi, Shingavada, Machhundri, Adak, Raval and Jamri) of which at least four viz. Hiran, Shingavada, Machhundri and Raval are perennial (i.e. flowing throughout the year excepting during droughts). These four have been dammed resulting in the creation of four reservoirs at Kamleshwar, Jamwala, near Babaria and near Jasadhar respectively (Fig-1). There are some more rivers which have their catchment areas in Gir and some which pass adjacent to the administrative boundaries of the PA. Many small and large seasonal streams (locally called 'chhel') crisscross the whole landscape and ultimately meet the larger rivers.

2.3.2 CLIMATE - The climate is tropical monsoonal with three distinct seasons viz. winter (Nov.-Feb.), summer (Mar.-June.) and monsoon (July.-Oct.). However, the months of March, June and October represent the transition between three seasons respectively and therefore show a mixed pattern of climate. Much of the rain is received in mid June to September through the Southwest monsoon(Khan *et al.* 1990). Rainfall is high in the West and gradually decreases as one goes Eastward (Fig- 2). The minimum temperature goes to 4^0 (winter) and maximum to 45^0 (summer). Relative humidity varies between 10 % and 100% (pers. obs.).

Fig. 2 Mean Rainfall Pattern at Different Places in and Around the Gir Lion Sanctuary



PLACE	YEARS
MENDARDA	10
TALALA	10
VISAVADAR	10
KAMLESHWAR	29
UNA	10
RAVAL	11
KHAMBA	2

[SOURCE: Khan *et al.* 1990]

2.4 BIOTIC COMPONENTS:

2.4.1 VEGETATION - The vegetation of this PA can be broadly classified into Tropical dry deciduous forest, Tropical thorn forest and Tropical dry evergreen (riparian) forest (Champion & Seth 1968). The floristic inventory of the PA was made by Santapau and Raizada (1956), while Berwick (1974) and Khan *et al.*(1990) attempted a classification of Gir vegetation during their studies on the ungulates of the PA. There is no detailed vegetation map available for the area, but Sharma (unpubl. data) is preparing a vegetation map based on aerial photographs, satellite imageries and ground truthing. This preliminary map has formed the basis for my vegetation sampling during the course of this study.

The three major vegetation types show many more communities and floristic associations which will be dealt with in the results. Here, I will try to present a broad and general picture of the vegetation of the Gir PA. The deciduous forests of West and central Gir are dominated by Teak (*Tectona grandis*) whose various associations cover about 70% of the area of the PA (Khan *et al.* 1990). Common associates of teak in the canopy are, *Acacia* spp, (4 species), *Diospyros melanoxylon, Ficus bengalensis, Lannea coromandelica, Boswellia serrata, Wrightia tinctoria, Manilkara hexandra, Terminalia tomentosa, Mitragyna parviflora, Adina cordifolia and Phyllanthes emblica.* Understorey is commonly comprised of *Zizyphus mauritiana, Z. oenoplia, Butea monosperma, Xeromphis spinosa, Flacourtia indica, Aegle marmelos* and *Wrightia tinctoria* as well as saplings of the canopy forming trees. Common shrubs are *Carissa carandas, Helicteris isora, Capparis sepiaria* and *Zizyphus* spp. Herbs such as *Cassia tora, Achyranthes aspera, Barleria prionitis, Sida acuta* etc. emerge during monsoon and stay till mid-winter. Seventy one species of grasses have been reported from Gir (Berwick 1974) of which the commoner ones are *Dendrocalamus strictus*, *Apluda mutica*, *Themeda quadrivalvis*, *Eragrostis* spp., *Heteropogon contortus*, *Chloris dolichostachys* and *Saccharum spontaneum*. Eastern portion has *Anogeissus latifolia* replacing teak and its common associates are, *Acacia* spp., *Boswellia serrata*, *Terminalia tomentosa* and *Wrightia tinctoria*. This region has savnnah like appearance. There are patches of thorn woodland throughout the region having *Acacias* and *Zizyphus* as major species with grass. Riparian vegetation is dominated by *Syzygium rubicunda*, *S. cumini*, *Pongamia pinnata*, *Tamarindus indica*, *Ficus bengalensis*, *F.glomerata*, *Manilkara hexandra*, *Sterculia urens*, *Butea monosperma* and bushes of *Carissa*, *Zizyphus*. There are grasses in the river bed (*Saccharum* and *Typha angustifolia* patches) and the undergrowth is generally dense.

2.4.2 FAUNA - Gir is the last refuge of the Asiatic Lion (*Panthera leo persica*), whose only wild population thrives here. Apart from lion, Gir has mammals such as leopard (*Panthera pardus*), striped hyena (*Hyaena hyaena*), jungle cat (*Felis chaus*), rustyspotted cat (*Felis rubiginosa*), jackal (*Canis aureus*), small Indian civet (*Viverricula indica*), ratel (*Mellivora capensis*), sambar (*Cervus unicolor*), nilgai (*Boselaphus tragocamelus*), chital (*Cervus axis*), chousinga (*Tetracerus quadricornis*), chinkara (*Gazella gazella bennetti*), Wild pig (*Sus scrofa*), common langur (*Presbytis entellus*), Indian crested porcupine (*Hystrix indica*), Indian hare (*Lepus nigricollis*) and Indian pangolin (*Manis crassicaudata*) (Spillet, 1974).

Two hundred and fifty species of birds, including a large number of raptors are found here. There is no detailed listing of reptiles, but the available information and my own observations have revealed ca 25 spp. The major reptiles are mugger (*Crocodilus palustris*), monitor lizard (*Varanus bengalensis*), garden lizard (*Calotes versicolor*), chameleon (*Chameleo zeylanicus*), skink (*Mabuya spp.*), Indian rock python (*Python molurus*), cobra (*Naja naja*), russel's viper (*Vipera russelli*), saw-scaled viper (*Echis carinatus*), common krait (*Bungarus caeruleus*), rat snake (*Ptyas mucosus*), checkered keel back (*Xenochropis piscator*) and wolf snake (*Lycodon aulicus*). No published information is available on amphibians and fishes occuring in the PA.

2.5 ANTHROPOGENIC ACTIVITIES:

2.5.1 CULTIVATION - Cultivation is found in all the peripheral villages around Gir as well as in certain pockets inside the Sanctuary. This has evident direct as well as indirect deleterious impacts on the forest. However, N.P. is completely free from agriculture.

2.5.2 MALDHARIS AND GRAZING - Maldharis are local pastoralists who have changed from nomadism to settled life in Gir PA. They and their buffaloes have been the part of this ecosystem since a long time. Till 1972, there were 129 maldhari settlements (locally known as 'ness', Khan *et al.*, 1990), but from 1972 to 1992 many 'nesses' have been moved outside the PA. Presently there are 65 'nesses' in the sanctuary. There is no 'ness' inside the N.P. These active and abandoned ness sites have characteristic appearance with open thorn woodland or degraded forest in the surrounding area. Apart from the buffaloes of maldharis, a fairly large cattle population and a few goats graze in the PA. Grazing is not permitted inside the National Park.

2.5.3 MISCELLANEOUS ACTIVITIES - Fuel wood collection, grass cutting and collection of non-wood forest produce such as fruits of *Syzygium, Zizyphus, Diospyros, Phyllanthes emblica* and *Carissa*, honey and gum also goes on regularly.

2.6 MANAGEMENT INPUTS: The Sanctuary and N.P. are being managed by the Gujarat state forest department. Logging stopped with the advent of WildlifeL (Protection) Act, 1972. N.P. (258 km^2) was declared in 1972 giving this area legal protection from all forms of anthropogenic activities including tourism which is restricted to certain pre-decided routes in the Western portion of the Sanctuary. Important management practices include burning of fire lines, grass-harvesting and provision of water at artificial waterholes in summer. A five yearly (waterhole) census for the two major predators (lion and leopard) and regular annual counts (vehicle counts) of ungulates and peafowl are also carried out. A management plan is under preparation by Mr. S. Tikadar.

2.7 PAST RESEARCH: Gir has been a focal point for many scientific studies providing a wealth of information on its various aspects. Floristics and aspects of vegetation were studied by Santapau and Raizada (1956). Hodd (1969) worked on the impacts of maldharis on Gir vegetation. Berwick (1974) and Khan (1990) provided information on population parameters, dietary components and habitat use by major ungulates in the PA. Joslin (1973) worked on the ecology and behaviour of lion. Sinha (1987) worked on the ecology of the Gir forest and researched the predatory patterns of lion. Ravi Chellam (1993) concentrated on the ranging pattern and predation ecology of the lions using radio telemetry.

Currently, two research projects of the Wildlife Institute of India are going on. These entail the ecology of mugger (Choudhary, unpubl. data) and assessing the impacts of management practices on the habitat (Sharma, unpubl. data).

2.8 INTENSIVE STUDY SITES: As Western, Central and Eastern Gir differ in vegetation, topography and degree of human interference, three study sites were selected in these three portions of the PA. These were Sasan (West Gir - Sanctuary), Chhodavdi (Central Gir - N.P.) and Dodhi (East Gir - Sanctuary) [See Fig-1 for the location of these 3 sites]. Sasan was the focal study site where about eighty percent of the total data collection time was spent. The two other areas were visited once each in winter and summer.

CHAPTER 3: METHODS

Habitat selection studies often involve a variety of approaches to the understanding of the problem. There are two basic approaches viz. direct and indirect to study habitat use/selection. The former involves collection of information based on direct sightings of the animal(s) indicating abundance of animals and intensity of use, while the latter depends on evidences (such as droppings, tracks etc.). In this study, I followed the direct approach to understand habitat choice pattern of the peafowl in the Gir PA.

3.1 PEAFOWL ABUNDANCE: Many methods such as spot-mapping, point counts and line transects are available for avian abundance estimation (Shields 1979; Verner 1985). Spot-mapping generally doesn't take into account 'floaters' and younger age classes and is good for terrestrial birds during the breeding season (Verner 1985). With point counts it is difficult to cover large areas and there are problems involved in applying this method in forested areas due to hampered visibility. Also, these counts work well with small birds, peafowl however get flushed when the point is approached (N.D. Rai, pers. comm.). On the other hand, line transects can cover large areas, are equally during breeding as well as non-breeding season and are also cost effective. These characteristics therefore made line transects the most suitable sampling method for this study. Line transects of variable width were used to get sightings (indicating abundance of the birds) and ultimately the intensity of use for different habitats.

Transects were laid proportionately in N.P. and Sanctuary. In all, 10 transects were laid of which 5 were around Sasan (West Gir - Sanctuary; Total length - 6.7 kms.), 2 at Dodhi (East Gir - Sanctuary; Total length - 3.3 kms.) and 3 at Chhodavdi (Central Gir - N.P.; Total length - 2.2 kms.). These transects reflected the availability of different topographical and floral features with all plant communities of Gir PA (Based on the preliminary vegetation map of Sharma [unpubl. data]) being represented. Salient features of these transects have been outlined in appendix-4. All transects in West Gir were walked 6 times each in winter and summer, while at the other two study sites, each transect was walked thrice in winter and summer. This was simply due to the fact that Sasan in West Gir was the base for this study. Transects were mainly walked during early morning and evening, but riverine transect was walked during afternoon also to sight the resting animals. While walking these transects, the following parameters were noted: number of peafowl, sex, age (classified as chick, immature and adult), perpendicular distance of the bird(s) from the line, time of sighting, activity of the birds, terrain features and vegetation type (where clearly identifiable). The densities were obtained using Fourier Series Estimator (Burnham *et al.* 1980) as it is one of the most robust estimator available.

3.2 HABITAT USE: Habitat preference/selection is determined by comparing the availability of the habitats with their utilization. This gives an indication of whether the resource/habitat is used more or less than availability. Therefore, quantitative data on habitat (and its resources) availability and utilization was collected for using it in standard availability-utilization methods (such as Neu *et al.* 1974; Johnson 1980; Hobaugh 1984 among others).

Availability data was collected on each transect at every 100 m twice (once each in winter and summer) during the course of the study. This is a nonmapping technique described by Riney (1982) and a modification of the method used by Marcum and Loftsgaarden (1980). Tree species and their number was recorded in an estimated 10 m radius plot. Shrub species and their numbers were noted in an estimated 4 m radius plot. For both the purposes nylon rope was used. Herb species and their numbers were recorded in a 1 m radius plot. Phenophase (These were: sprouting leaves, green leaves & ripe leaves, leafless, flowering and fruiting) of every tree and shrub species was also recorded along with their abundances. GBH of the trees was measured. A modification of the two step method (Sale & Berkmuller 1988) was used to obtain grass, litter and canopy availability. Twenty five paces each were walked in four directions from every hundred metre point and at every pace, the object (i.e. grass or litter) to which the tip of the shoe touched was noted. Also, by looking up at every step, presence or absence of canopy was recorded. For presence and absence of these three variables scores 1 and 0 were given and the total was taken as their percentage availability. Average grass and herb height were also recorded. Availability of cover was obtained by using chequer board method. The number of visible squares in the chequer board were counted at two heights : 0.45 metres (which is the height of most of the body of peafowl) and 0.75 metre (where the neck and head of peafowl will reach). Cattle dung was counted in 10m plot. Terrain features were qualitatively recorded as flat, undulating and hilly. Grasshopper abundance was quantified along a two hundred metre long and two metre wide transect in every plant community. Other insects were also noted if observed at that time.

For lizards (i.e. *Calotes* and *Sitana* which are known dietary items of peafowl) also, transects of the same length and width were used. Utilization information was collected by the same methods at every point of bird's sighting. Two additional factors viz. distance (perpendicular) of the sighting from the nearest water source and human habitation were also noted for utilization data.

3.3 ROOST TREE USE: Different localities in three study sites were surveyed for roost tree use by peafowl. Both, direct and indirect methods were used to locate/identify the roost trees. The former involved walking along the riparian areas during late evening or in early morning to disturb the roosting birds and locating the trees. The latter technique involved searching for droppings below potential roost trees to identify actual roost trees. When a roost tree was located, GBH, height of the first branch, tree height, slope category (very steep, steep, gradual, flat), distance from water (or water body), canopy and understorey characteristics were recorded. Same data was collected on the ten nearest trees from the used tree, to get availbility information. In all 1034 trees (of which 128 were roost trees) were quantified in this way.

3.4 ACTIVITY PATTERN AND DROPPING ANALYSIS: Group scan sampling (Altmann, 1974) was carried out for 4 and 2 days each in winter and summer respectively to supplement the existing information collected on transects with activity pattern, habitat use, food species and other miscellaneous data.

Droppings of peafowl were examined for food remains by breaking open fresh dry droppings and remains were noted in the form of frequency of occurrence. Most of peafowl droppings were found in river/stream beds. So, this work was done in open riverine (9 different localities) areas.

3.5 STATISTICAL ANALYSES: A wide array of methods exists for the analysis of habitat/ resource preference by availability-utilization data (e.g. Friedman 1937 in Alldredge & Ratti 1986; Neu *et al.* 1974; Quade 1979 in Alldredge & Ratti 1986; Johnson 1980 among others). The subject of choosing the best method from the existing ones has received exhaustive treatment from Alldredge and Ratti (1986, 1992), who finally have drawn the conclusion that no single method can be regarded as the best and selection of the method cannot be entirely objective. However, all these methods require the independence of sightings. In the case of peafowl, group size varied from one to fifteen and it would be erroneous to treat the sightings of one bird and fifteen birds as one occurrence. Therefore, Habitat Use Index (HUI) was used to show the intensity of usage. This has been widely used in bird studies and has been treated with various names in literature (e.g. Bhupathy 1991). Hobaugh (1984) also used it effectively in his study on habitat use by snow geese. Intensity of use is obtained by the formula:

$$HUI = \frac{\text{\% utilization (here number of birds)}}{\text{\% availability (here number of points)}}$$

HUI was calculated for both, the number of sightings as well as number of animals. Both produced similar results and were highly significantly correlated (Spearman's rank correlation coefficient, $r=0.857$, $p< 0.01$). This gave me the freedom to overcome the problem of independence of sightings. The visibility differed in different plant communities. Serious biases can creep in if care is not taken regarding unequal visibility in habitat use studies. In my case, however these differences did not cause any significant distortion due to the fact that opener habitats which had a very high visibility were too small, whereas denser habitats were in long stretches. Hence, the effective area sampled did not vary much. So, Neu et al.(1974) technique was used to compare availability-use of the habitats based on the number of sightings. A computer programme PREFER (developed by Prasad & Gupta, W.I.I.) was used to calculate bonferroni intervals and significance of differences in habitat use. Preference index (PI) was (see Bhupathy 1991 for elaborate treatment of this method) calculated for some structural parameters of the roost trees using essentially the same formula as that of HUI. Calculations and appropriate parametric and nonparametric statistical tests were carried out manually as well as by using Software package SPSS/PC+. A significance level of 0.05 was set for any statistical test carried out.

CHAPTER 4: RESULTS

4.1 PLANT COMMUNITY DESCRIPTION: Based on the vegetation quantification, thirteen plant communities were identified of which ten occurred in Sasan, six in Chhodavdi and four in Dodhi. Major qualitative and quantitative features of these communities are described in brief below and summarised in table-1:

4.1.1 RIPARIAN FOREST (RIP) - This occurs along the rivers and streams throughout the PA. Two distinct associations are recognized i.e. mature riverine forest with *Syzygium rubicunda, S. cumini, Pongamia pinnata, Ficus glomerata* and *Tamarindus indica* dominating and mixed riverine forest comprised mainly of *Manilkara hexandra, Wrightia tinctoria, Acacia catechu, Butea monosperma* and *Sterculia urens.* The former occurs along the moister perennial water sources, while the latter is mostly found on the rocky banks of seasonal streams. Understorey is luxuriant in both the associations with shrubs of *Carissa, Zizyphus oenoplia, Z. mauritiana* and *Ixora parviflora* dominating. Profuse regeneration of the canopy trees is also found. Herb layer chiefly consists of *Cassia tora, Achyranthes aspera, Sida* spp. Canopy is dense (50-60 % avg.) and litter accumulation moderate. Average tree, shrub and herb densities per hectare are 341, 1507 and 69154.

4.1.2 TEAK - ACACIA COMMUNITY (TA) - This community is characterized by the dominance of teak (*Tectona grandis*) and five *Acacia* spp. (mainly *A.catechu, A.nilotica* and *A.leucophloea*) which together constitute > 50 % of the total trees. Teak alone contributes ca 40 % of the trees. This association seems to be a degradational stage of teak mixed forest due to past forestry practices. Apart from teak and Acacias, there are *Diospyros*

TABLE:1 AVERAGE VALUES OF SOME HABITAT VARIABLES FOR PLANT COMMUNITIES

COMM	TD	SD	HD	GR HT	HB HT	GRAS S	LIT	CAN	VIS 1	VIS 2
TMF	716	1982	87643	56	51	37	62	62	37	49
TA	476	904	69665	31	39	44	46	43	60	78
RIP	341	1507	69154	25	56	44	35	37	58	64
TMF-H	618	2189	24204	78	39	45	54	42	42	65
TW	264	390	54273	15	22	60	24	23	83	92
SAV	64	354	1769	24	5	73	17	6	78	91
SCR	26	995	47134	6	33	65	10	4	82	100
LB	382	796	84395	35	50	50	60	33	75	100
DF	276	1327	133758	20	31	52	35	28	71	73
CULT	0	0	3184	7	15	36	5	3	100	100
PTW	206	2090	9554	50	30	17	51	38	64	59
AA	268	979	32909	9	17	63	34	20	87	98
AMF	358	2736	40605	36	19	57	45	36	57	88

ALL THE VALUES HAVE BEEN ROUNDED UP.
COMM= Community, TD=Tree density, SD=Shrub density, HB=Herb density, LIT=Litter, CAN=Canopy, GR HT=Grass height, HB HT=Herb height, VIS1=Visibility at 0.45 m; VIS2=Visibility at 0.75 m

melanoxylon, Bauhinia racemosa, Wrightia tinctoria and *Zizyphus mauritiana* in canopy and understorey. Major shrubs are *Capparis sepiaria, Zizyphus mauritiana, Z.oenoplia, Barleria prionitis. Cassia tora, Triumfetta rotundifolia*, and *Sida* spp dominate the herb layer. Average tree, shrub and herb densities are 476, 904 and 69665. Canopy is more open and grass cover is 40-50 percent. This community is mostly found on flat and undulating areas.

4.1.3 TEAK MIXED FOREST (TMF) - This forest has higher tree species richness, reduced abundance of *Acacia* spp and more luxuriance than the former (i.e.TA). Generally >7 tree species are present. Common associates of teak in the canopy are *Aegle marmelos, Butea monosperma, Diospyros melanoxylon, Mitragyna parviflora* and *Morinda tinctoria* whereas *Zizyphus xylopyrus, Z.mauritiana* and *Phyllanthes emblica* are present in the understorey. Teak accounts for nearly 48 % of the trees. Undergrowth is dense with shrubs of *Helicteris isora, Carissa, Zizyphus mauritiana, Z. oenoplia* and *Holarrhena antidysenterica*. Common herbs are *Cassia tora, Sida* spp, *Achyranthes aspera, Neurocanthes* and *Triumfetta*. Canopy is thick (60-70 %) and litter cover high (60-70 %). This forest occurs in flat and undulating areas. Average tree, shrub and herb densities are 716, 1982 and 87643.

4.1.4 TEAK MIXED FOREST - HILL (TMF-H) - Physical features and species composition of TMF changes in the hilly areas and hence this community is named TMF-H. Appearance and preponderance of *Soymida febrifuga, Wrightia tinctoria, Boswellia serrata, Acacia ferruginea* and *Dalbergia latifolia* mark this association. Forest is less dense than TMF in flat areas. Teak forms nearly 57 % of the total individuals. Shrub layer is mainly composed of

Helicteris isora, *Barleria* and *H. dysenterica*. *Neurocanthes*, *Peristrophe* spp. and *Triumfetta rotundifolia* are major herbs. Grass growth is good and grasses such as *Apluda mutica* reach considerable height(upto 2 m). Average tree, shrub and herb densities are 618, 2189 and 24204.

4.1.5 PURE TEAK WOODLAND (PTW) - Many areas in Gir PA have monocultures of teak. Moreover, in certain hilly regions teak attains a high dominance contributing >80 % of the trees. Both these types together fall under this category of PTW. Other trees found here in very small numbers are *Zizyphus mauritiana*, *Acacia leucophloea* and *Wrightia tinctoria*. The forest is open and mostly lacks good undergrowth. Grass growth is very poor (10-20 %). Average tree, shrub and herb densities are 206, 2090 and 9554 respectively.

4.1.6 DEGRADED FOREST (DF) - This community arises as a result of anthropogenic influence (e.g. cutting, repeated collection of some shrubs and livestock grazing) and therefore is found around human dwellings (villages and 'nesses'). Canopy is very open and undergrowth mostly consists of thorny and unpalatable species. All the degraded forests fall in this category irrespective of the original community from which these have been derived. Scattered trees of teak, *Wrighta tinctoria*, *Butea monosperma* and *Holoptelia integrifolia* are found. Shrubs are mainly *Capparis sepiaria*, *Calotropis procera*, *Zizyphus mauritiana*. *Xanthium spp.*, *Cassia tora*, *T. rotundifolia* and *Hibiscus spp.* dominate the herb stratum.

4.1.7 LANNEA-BOSWELLIA COMMUNITY (LB) - This is found along the rocky stream banks in hills and also on the steeper rocky slopes. *Lannea coromandelica* and *Boswellia serrata* are the chief floral elements contributing >50 % of the total trees. *Acacia* *leucophloea, A. catechu* and *Tectona grandis* may also be found associated with this type. This is an open community with good grass cover (60-70 %) and moderate canopy (30-40 %). Shrub layer is poorly represented. Major herbs are *Neurocanthes, Triumfetta* and *Peristrophe*. Average tree, shrub and herb densities are 382, 796 and 84395.

4.1.8 THORN WOODLAND (TW) - This community is characterized by the preponderance of thorny tree species in the canopy. Major tree species are *Acacia nilotica, A. catechu, A. leucophloea* and *Zizyphus mauritiana*. Trees such as *Bauhinia racemosa* are present in meagre numbers in some areas. TW is mainly restricted around 'ness' sites in Western and Central Gir, but in East Gir it is quite widespread in other areas too probably owing to lower rainfall and low site quality. It lacks an understorey of trees. Only in East Gir it attains a complex structure and thick undergrowth. Thorny shrubs such as *Capparis sepiaria, Zizyphus mauritiana* and *Z. oenoplia* dominate. *Cassia tora* and *Achyranthes aspera* emerge as major herbs. Grass cover is high (60-70 %), but litter and canopy cover are low (20-30 %). Average tree, shrub and herb densities are 264, 390 and 54273.

4.1.9 SAVANNA (SAV) - Occurring in undulating and hilly regions throughout the PA, this community is in a high proportion only in East Gir, whereas in West and Central Gir its availability is less. This has a very low tree density (<100 trees/ha). Even shrubs and herbs are few or absent. Major trees are *Acacia catechu, A.leucophloea, Z. mauritiana* and *Anogeissus latifolia*. *Zizyphus mauritiana* and *C.sepiaria* represent the shrubs. *C. tora, Achyranthes aspera* and *Triumfetta* dominate the herb layer. Grass cover is high (70-80 %), while canopy is very open (0-10 %).

Average tree, shrub and herb densities are 64, 354 and 1769.

4.1.10 SCRUBLAND (SCR) - This represents an advanced degradational stage of any previously existing forest community due to human influence. Therefore this community is associated with human habitation. Trees are either absent or sparsely distributed. Most of the shrubs form thickets and this is a prominent feature of the community. *Z.numularia* is the commonest shrub forming thickets. *Z. mauritiana* and *Calotropis procera* also occur. Herbs such as *C. tora, T. rotundifolia, Xanthium spp.* are seen. Grass growth is good (60-70 %) and canopy cover is poor (0-10 %). Average tree, shrub and herb densities are 26, 995 and 47134.

4.1.11 ANOGEISSUS-ACACIA COMMUNITY (AA) - *Anogeissus latifolia* is restricted to East Gir and therefore two communities having *A. latifolia* were present only on the transects of Dodhi. AA is an open forest community with *A. latifolia* and *Acacia* spp. (mostly *A. catechu*) contributing >50 % of the total trees. *A. latifolia* alone accounts for 42 % of the trees. *Diospyros melanoxylon, Bauhinia racemosa, Terminalia tomentosa* and *Zizyphus mauritiana* are also present. *Z. mauritiana* and *Capparis sepiaria* are the most abundant shrubs. *Cassia tora* and *Triumfetta* are major herbs. High grass cover (60-70 %) and low canopy cover (20-30 %) are important features. Average tree, shrub and herb densities are 268, 979 and 32909.

4.1.12 ANOGEISSUS MIXED FOREST (AMF) - This is comparable to TMF of West and Central Gir, the only difference being that teak is replaced by *A. latifolia*. *A.latifolia* accounts for ca 25 % of the trees. Tree species richness increases dramatically with 7-8 species appearing instead of the usual 3-4. It is found in moister localities including stream banks. Apart from *A. latifolia*, trees in the canopy and understorey are *D. melanoxylon*, *B. monosperma*, *Morinda tinctoria*, *Wrightia tinctoria*, *Lannea coromandelica* and *Z. mauritiana*. *Helicteris isora*, *Carissa*, *Z. mauritiana* and *C. sepiaria* dominate the shrub layer. *Cassia tora* and *Sida* spp are found in the herb stratum. Average tree, shrub and herb densities are 358, 2736 and 40605.

4.1.13 CULTIVATION (CULT) - Cultivation is present only in certain parts of the PA in settlement villages. It is generally surrounded by forest hence creating a forest-agriculture mosaic on the landscape. Major crops grown during the study period were groundnut, wheat, cotton, sugarcane, gram and corn. Hedges of the cultivated fields have also been included in this category.

4.2 HABITAT SELECTION:

For the sake of convenience and clarity, this chapter has been divided into six sections and the data presented accordingly.

4.2.1 PEAFOWL ABUNDANCE AND DISTRIBUTION - Density estimates obtained for three different regions of Gir PA are shown in table-2. The hypothesis that densities will vary between Sanctuary and N.P. is accepted. The magnitude of variation in the density figures is suggestive of uneven distribution of peafowl in the Gir PA with a density gradient from West to East. Sightings of peafowl did not occur with equal frequency in all hundred metre segments of the transects, instead these were concentrated in certain segments only. These evidences indicate the clumped nature of peafowl distribution in Gir. The degree of clumping also seems to vary.

4.2.2 PLANT COMMUNITY SELECTION - I have used the term habitat loosely for plant communities as well as the sum of physical and biological factors in the landscape. Habitat use index (HUI) for

TABLE:2 PEAFOWL DENSITY (per km^2) FOR THREE STUDY SITES IN THE GIR PA

REGION	GROUP DENSITY	STD.ERROR	COEFF. OF VAR.	CONF.LIMITS	DENSITY (*)
1. WEST GIR (SANCTUARY)	284.1	64.86	22.8 %	104.0-464.2	866.5
2. CENTRAL GIR (N.P.)	120.5	52.02	43.2 %	-103.3-344.4	289.2
3. EAST GIR (SANCTUARY)	64.68	33.67	52.1 %	-363.1-492.5	188.9

Based on Fourier series estimator, Burnham et al. 1980.

* Density is obtained by multiplying group density with mean group size for that region.

different plant communities in Sasan is shown in table-3. The results of analysis for availability-use (using the technique of Neu *et al.* 1974) are shown in table-4. It is evident that both the techniques showed similar results. The hypothesis that there will be differences in intensity of use of habitats is accepted. RIP, CULT and DF were used more than their availability; SAV, SCR and TW were used according to availability, while TMF and TA were used less than their availability. TMF(H) and LB were null habitats with no sightings. For Chhodavdi and Dodhi, only HUI was calculated owing to the small (40 sightings) sample size. In Chhodavdi, habitats were used in the following intensity: PTW, TA, RIP, SAV, TMF(H) and TMF (Table-5). In Dodhi, the intensity of use for habitats was: TW, AMF, SAV and AA (Table-5). In Chhodavdi TW and in Dodhi RIP were not represented in the availability (due to insufficient sampling), but they showed up in usage. These habitats have been removed from the analysis therefore.

4.2.3 STRUCTURAL FEATURES - A Pearson's correlation between the mean values of all habitat variables across the plant communities was carried out and the resultant correlation matrix is displayed in table-6. This correlation helped in reducing the dimensionality of the original data set. Only four variables (i.e. tree density, shrub density, grass height and herb height) were therefore considered in further analyses. For these four variables, availability-use analysis using the technique of Neu *et al.* (1974) was carried out. Tree density was categorised in classes of 100 trees per hectare (classes were: 0-100, 100-200, 200-300, 300-400, 400-500, 500-600, 600-700 and >700). Tree density class 0-100/ha was used more than availability, whereas >700 trees/ha category was used less than its availability and rest were used in proportion to

TABLE:3 HUI FOR HABITATS IN SASAN

	OVERALL			WINTER		SUMMER	
COMMUNITY	% AVAILABILITY	% USE	HUI	% USE	HUI	% USE	HUI
TW	15	8.7 (10.8)	0.58 (0.72)	9.7 (10.3)	0.65 (0.69)	7.9 (11.2)	0.53 (0.75
TMF	20.5	11.5 (10.8)	0.56 (0.53)	13.3 (11.2)	0.65 (0.55)	10.0 (10.4)	0.49 (O.51
RIP	8.2	22.3 (20.4)	2.72 (2.49)	20.5 (20.7)	2.50 (2.52)	23.8 (20.1)	2.90 (2.45
SAV	2.7	2.5 (1.6)	0.92 (0.59)	1.8 (0.9)	0.67 (0.33)	3.0 (2.2)	1.11 (0.81
TA	24.6	13.1 (16.8)	0.53 (0.68)	13.0 (15.5)	0.53 (0.63)	13.1 (17.9)	0.53 (0.73
SCR	6.8	10.2 (10.0)	1.5 (1.47)	8.4 (7.8)	1.23 (1.15)	11.8 (11.9)	1.73 (1.75
DF	8.2	11.2 (16.0)	1.36 (1.95)	13.0 (19.8)	1.58 (2.41)	9.6 (12.7)	1.17 (1.55
CULT	2.7	20.5 (13.6)	7.59 (5.04)	20.2 (13.8)	7.48 (5.11)	20.7 (13.4)	7.67 (4.96
TMF (H)	8.2	0	0	0	0	0	0
LB	2.7	0	0	0	0	0	0

FIGURES IN PARENTHESIS INDICATE THE HUI VALUES FOR NUMBER OF ANIMALS

TABLE:4 AVAILABILITY-USE ANALYSIS FOR HABITATS USING Neu *et al.* (1974) TECHNIQUE

HABITAT CATEGORY	RELATIVE AREA	EXPECTED USAGE	OBSERVED USAGE	CONFIDENCE INTERVALS
TA	0.246	61.50	42	0.102 - 0.234 *
TMF	0.205	51.25	27	0.053 - 0.163 *
TMF(H)	0.082	20.50	0	0.000 - 0.000 *
TW	0.150	37.50	27	0.053 - 0.163
CULT	0.027	6.75	34	0.075 - 0.197 **
RIP	0.082	20.50	51	0.132 - 0.276 **
SCR	0.068	17.00	25	0.047 - 0.153
LB	0.027	6.75	0	0.000 - 0.000 *
SAV	0.027	6.75	4	0.000 - 0.038
DF	0.082	20.50	40	0.095 - 0.225 **

FOR FULL FORMS OF THE HABITAT CATEGORIES SEE TEXT (SECTION:4.1)

* Indicates that the habitat was used less than availability.
** Indicates that the habitat was used more than availability.
Rest were used according to availability.
z=2.8099, x^2= 225.56

TABLE:5 HUI VALUES FOR CHHODAVDI AND DODHI

CHHODAVDI (OVERALL)				DODHI (OVERALL)			
COMM	% AVAILABILITY	% USE	HUI	COMM	% AVAILABILITY	%USE	HUI
TMF	40	7.6 (10.0)	0.19 (0.25)	TW	37.1	67.7 (65.0)	1.82 (1.75)
TA	24	36.9 (37.5)	1.54 (1.56)	SAV	17.1	10.5 (10.0)	0.61 (0.58)
TMF (H)	20	7.6 (7.5)	0.38 (0.37)	AA	34.3	6.4 (7.5)	0.19 (0.22)
SAV	4	2.2 (5.0)	0.55 (1.25)	AMF	11.4	10.5 (12.5)	0.92 (1.10)
PTW	8	19.6 (15.0)	2.45 (1.87)	-	-	-	-
RIP	4	3.3 (2.5)	0.82 (0.62)	-	-	-	-

FIGURES IN THE PARENTHESIS INDICATE HUI VALUES FOR NUMBER OF ANIMALS

TABLE:6 RELATIONSHIPS BETWEEN SOME IMPORTANT HABITAT VARIABLES

VARIABLES		CORRELATION VALUES
TREE DENSITY	SHRUB DENSITY	0.6650 *
TREE DENSITY	GRASS HEIGHT	0.8422 **
TREE DENSITY	LITTER	0.9238 **
TREE DENSITY	CANOPY	0.9703 **
TREE DENSITY	VISIBILITY 1	- 0.8842 **
TREE DENSITY	VISIBILITY 2	- 0.7696 *
SHRUB DENSITY	GRASS HEIGHT	0.6653 *
SHRUB DENSITY	VISIBILITY 1	- 0.8137 **
CANOPY	SHRUB DENSITY	0.6757 *
CANOPY	LITTER	0.9106 **
CANOPY	VISIBILITY 1	- 0.8829 **
CANOPY	VISIBILITY 2	- 0.7969 **
GRASS HEIGHT	VISIBILITY 1	- 0.8699 **
GRASS HEIGHT	VISIBILITY 2	- 0.6874 *

* Indicates significance at 0.01 level.
** Indicates significance at 0.001 level.

their availability. The results remained same in both winter and summer (winter: x^2= 52.75, df=7, p<0.001; summer: x^2= 61.75, df=7, p<0.001). All shrub density classes (these were: 0-500, 500-1000, 1000-1500, 1500-2000, 2000-2500, 2500-3000 and >3000) were used in proportion to their availability during winter (x^2= 14.2, df=6, p<0.05) except the last two categories (i.e. >2500), which were used less than their availability. In summer also all except the last category (i.e. >2000) were used according to availability (x^2= 9.59, df=4, p<0.05). Shrub class >2000 was used less than availability. Grass height (the categories were: 0-15, 15-30, 30-45, 45-60 and >60 for winter; for summer: 0-15, 15-30, >30) of 0-15 cm was used more than its availability in winter as well as in summer. Grass height of 45-60 cm class was used according to availability in winter and the rest used less than their availability (x^2= 44.25, df=4, p<0.001). In summer however, 15-30 cm height class was used less than availability and >30 cm class was used according to availability (x^2= 12.55, df=2, p<0.01). During winter, herb height category (the categories were: 0-15, 15-30, 30-45, 45-60, >60) of 0-15 cm was proportionately used more, rest of the categories were used according to availability and >60 cm class was used less than availability (x^2= 28.61, df=4, p<0.001). In summer, the pattern changed drastically as 45-60 cm class was used more than availability and rest of the categories were used according to their availability (x^2= 28.57, df=4, p<0.001). Availability and use of tree density and shrub density for West, Central and East Gir were clubbed because all the categories of these variables were available in three sites and the data set did not get diluted by clubbing. For the rest of variables, only the data from Sasan was considered. Out of the three terrain categories, undulating terrain was used more than availability, flat terrain according to availbility and hilly areas were used less than their availability.

4.2.4 SEASONAL DIFFERENCES IN HABITAT USE - There was no significant difference in habitat use by peafowl between winter and summer (Wilcoxon matched pairs signed rank test, number of pairs n=8, Z= -1.6103, 2-tailed p= 0.1073, i.e. p>0.05). The hypothesis of an expected seasonal difference is thus rejected. The HUI ranks calculated for winter and summer (for Sasan) were highly correlated (Spearman's rank correlation coefficient, r=0.84, p<0.01) indicating a lack or minor seasonal differences in habitat use. However, on individual transects a few variations in the pattern of sightings were observed which will be discussed in the next chapter.

4.2.5 SEX AND AGE DIFFERENCES IN HABITAT USE - Male and female peafowl did not differ significantly in their use of habitat (Wilcoxon's test, n=8, T=16, p>0.05), indicating that the hypothesis of sex differences in habitat use is rejected. This is also evident from the HUI obtained for males and females separately (Table-7). This trend remained similar for East and Central Gir too. However, the numbers of male and female birds did vary in some habitats. Young birds were observed in six out of ten plant communities in Sasan. Nearly 81 % of the chicks were encountered in TMF and RIP, habitats with the densest undergrowth. Young (chicks) were closer to females in habitat use pattern as would be expected. Immature birds' habitat use resembled the pattern of adult birds.

4.2.6 GROUP SIZE DIFFERENCES BETWEEN HABITATS - Group size of Peafowl in different habitat types differed significantly (x^2=42,

TABLE:7 HUI OF MALE AND FEMALE PEAFOWL FOR HABITATS OF SASAN

PLANT COMMUNITY	%·AVAILABILITY	MALE		FEMALE	
		% USE	HUI	% USE	HUI
TW	15.0	11.5	0.77	6.6	0.44
TMF	20.5	8.5	0.41	10.8	0.53
RIP	8.2	12.5	1.51	26.5	3.23
SAV	2.7	1.8	0.67	2.4	0.89
TA	24.6	18.9	0.77	10.8	0.44
TMF(H)	8.2	-	-	-	-
SCR	6.8	11.5	1.70	10.2	1.50
DF	8.2	15.0	1.83	7.2	0.88
CULT	2.7	20.3	7.52	25.3	9.37
LB	2.7	-	-	-	-

HUI= HABITAT USE INDEX

df=24, $p<0.05$). Therefore, the hypothesis regarding variation in group size across the habitats (chapter:1, section - 1.3) was accepted. The overall distribution of group size across the habitats is depicted in fig- 3. Nearly twenty eight percent of the sightings were of solitary individuals whereas the rest (72 %) were of groups (ranging from 2-15 birds). Only in fifteen percent of the sightings, group size was greater than five individuals.

4.3 ROOST SITE AND TREE SELECTION: Roost sites were mainly located in riverine areas.

4.3.1 FLORISTICS- A total of twenty one species of trees were identified as roost trees (Appendix-3). Figure-4 shows the availability and use of these trees. *Holoptelia integrifolia, Tectona grandis, Pongamia pinnata, Syzigium rubicunda, Tamarindus indica* and *Diospyros melanoxylon* were the most common tree species available and used by peafowl. Availability-use analysis of these six species with Neu *et al.* (1974) method showed that only *H. integrifolia* and *P. pinnata* were used more than their availability; *T. grandis, S. rubicunda* and *D. melanoxylon* were used according to availability whereas *T. indica* was used less than its availability (table-8).

4.3.2 STRUCTURE - There was a significant difference between the use of trees with and without climber thickets in the canopy (Chi square test, x^2= 10.62, df=1, $p<0.01$). Similarly, there was also a significant difference between the use of trees with and without a thorny undergrowth (x^2= 24.61, df=1, $p<0.001$). Preference indices (PI) for various structural features such as slope, distance from water, height, height of first branch are given in table-9. Trees on very steep slopes were highly used, whereas

Fig-3 Peafowl group size in different habitats

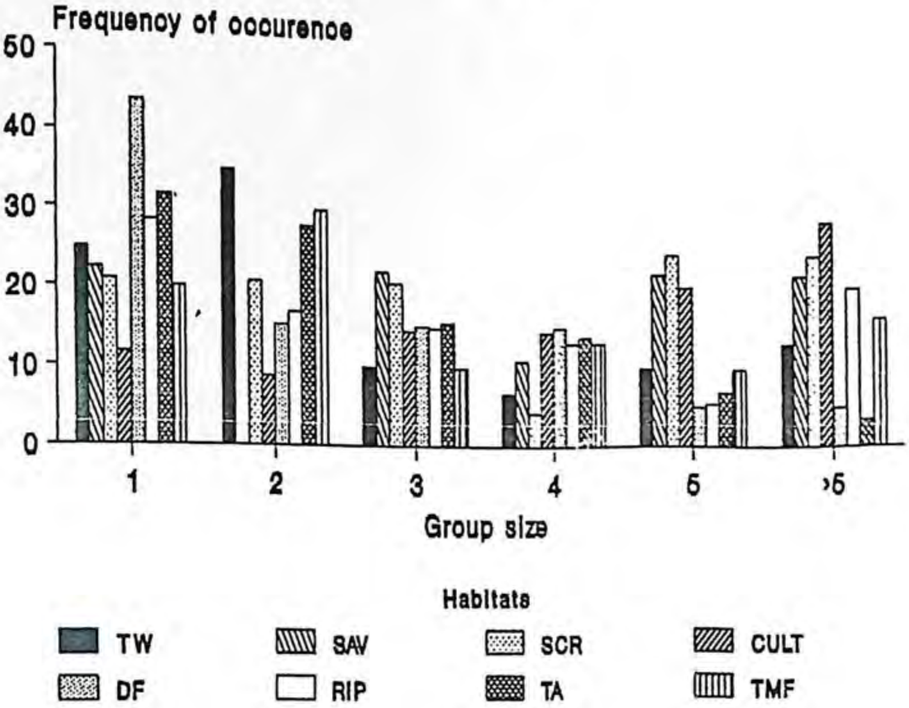
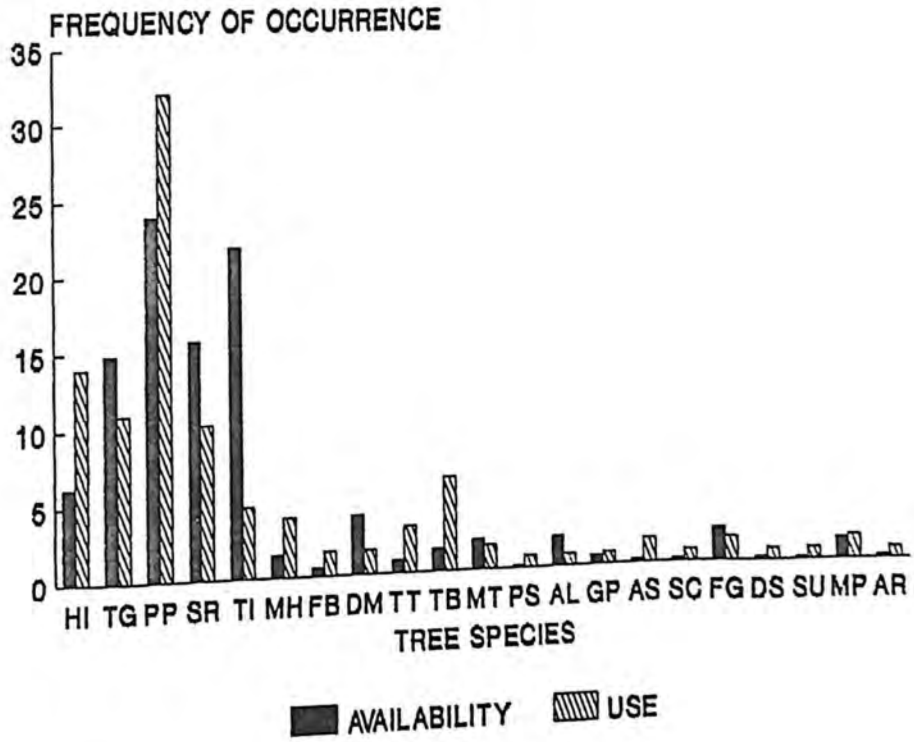


Fig-4 ROOST TREE USE BY PEAFOWL



FOR FULL NAMES OF THE SPECIES, SEE APPENDIX-VI

TABLE:8 ROOST TREE PREFERENCE BY PEAFOWL

(USING Neu *et al.* [1974] TECHNIQUE)

TREE SPECIES	RELATIVE AVAILABILITY	EXPECTED USAGE	OBSERVED USAGE	CONFIDENCE INTERVALS
HI	0.051	6.554	18	0.058 - 0.223 **
TG	0.124	15.846	14	0.035 - 0.184
PP	0.198	25.370	41	0.209 - 0.431 **
SR	0.131	16.717	13	0.030 - 0.173
TI	0.181	23.168	6	0.000 - 0.097 *
DM	0.033	4.224	2	0.000 - 0.045
OTH	0.282	36.096	34	0.161 - 0.371

FOR FULL NAMES OF THE SPECIES SEE APPENDIX-III. OTH=OTHER SPECIES.
* Indicates that the species was used less than availability.
** Indicates that the species was used more than availability.
Rest were used in proportion to availability.
$z=2.6899$, $x^2=45.36$

TABLE:9 PREFERENCE INDICES FOR SOME PHYSICAL FEATURES OF ROOST TREES USED BY PEAFOWL

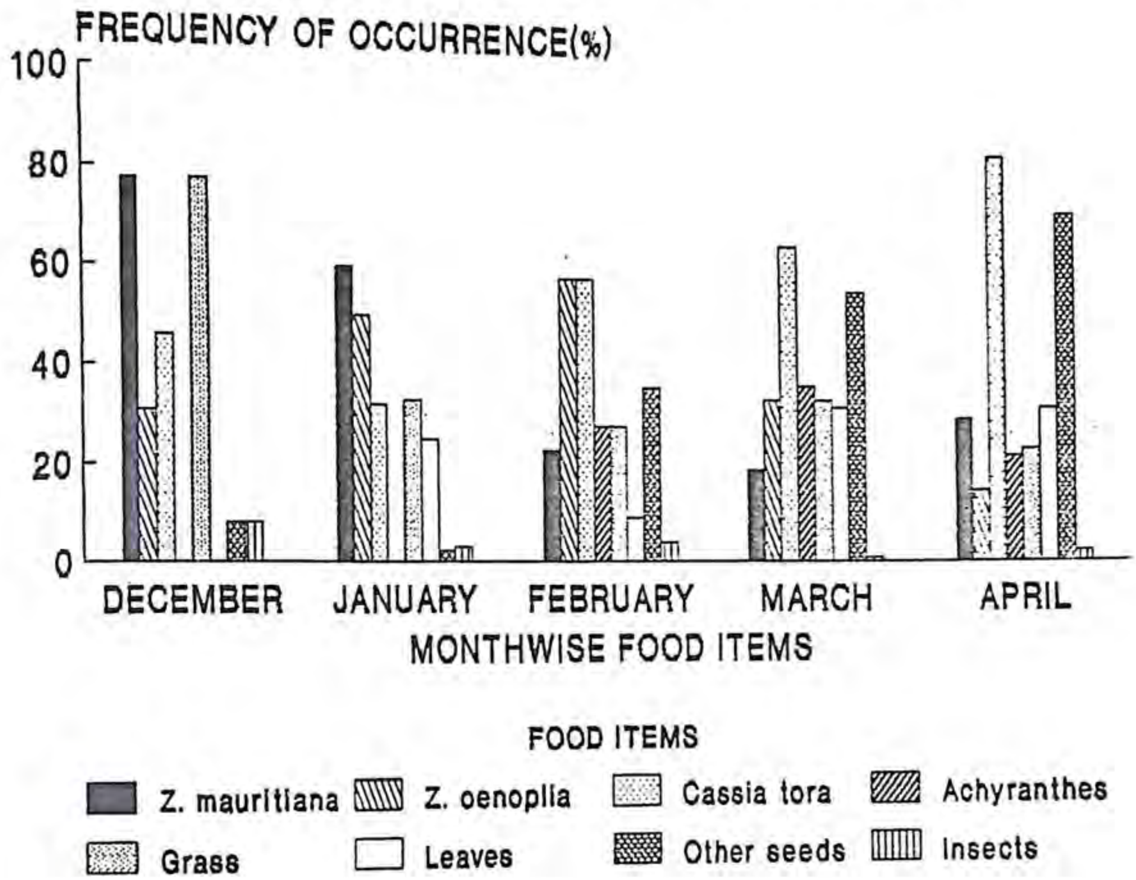
SLOPE CATEGORY		DISTANCE TO WATER(IN m)		HEIGHT		HEIGHT OF FIRST BRANCH	
CLASS	PI	CLASS	PI	CLASS	PI	CLASS	PI
VERY STEEP	1.45	0-25	1.00	<10	0.08	0-2	0.61
STEEP	0.81	25-50	0.87	11-15	3.38	2-4	1.73
GRADUAL	0.90	50-75	1.08	16-20	6.25	4-6	2.57
FLAT	0.60	75-100	0.73	21-25	8.10	6-8	2.69
-	-	> 100	0.73	>25	8.09	8-10	3.44

PI= PREFERNCE INDEX.

those on flat terrain were used least. All tree height categories above 15 metres were highly used, the least used being <10 m. Trees with 8-10 m high first branch were more used and the use went in a decreasing order towards 0-2 m height. Nearly ninety percent of the trees were within 75 metres from water.

4.4 DROPPING ANALYSIS - The results of dropping examination are shown in fig-5. During winter it was fruit that dominated the diet and gradually as summer approached, a shift towards granivory occurred. Animal matter (mostly invertebrates) was rarely observed in the droppings. This shows that during winter and summer peafowl were chiefly primary consumers. A list of dietary items of peafowl (confirmed by direct observations as well as dropping examination) is given in appendix-1.

DIET OF PEAFOWL
BASED ON DROPPING EXAMINATION



N=DEC-13,JAN-60,FEB-110,MAR-110,APR-135

CHAPTER 5: DISCUSSION

Patterns and processes in nature are sensitive to the scale at which they are viewed (Wiens 1985). Conclusions drawn from a study will then naturally depend on the scale at which the study was carried out. My study may be regarded as a broad and coarse scale investigation owing to two major reasons:

(i) It was carried out over a very short period (i.e. 5 months).

(ii) Knowledge on the ecology of a species greatly enhances the ease of drawing conclusions regarding habitat selection. But, in the case of peafowl this baseline ecological information is lacking.

However, at the same time it should be stressed that this was the best approach within the given constraints. In this section my effort is to obtain an overall picture of habitat selection by peafowl and discuss the factors influencing it.

5.1 PEAFOWL ABUNDANCE AND DISTRIBUTION: Density estimates appear to be extremely high and inflated especially for West Gir. However, the purpose of giving densities here is not to extrapolate and arrive at a population figure, but simply to compare the abundance of different regions using a standard method. Moreover, there are no comparable density estimates available except one. Large variation in the densities of peafowl between West, Central and East Gir are self explanatory of the differences in resource availability in these three regions. Observed density differences can probably be due to following reasons:

(i) West Gir is dominated by broad lowlying valleys and flat areas, which are less in East Gir. Peafowl is a bird of valleys and flat areas which is corroborated by their extremely high densities in West as compared to East (Table-2).

(ii) Due to higher rainfall (Fig-2), the productivity of West Gir should be the highest followed by Central and East. Insects and other small invertebrates which can form a significant portion of the diet of young peafowl will be expected to be higher in moister regions than arid areas. Lush and tender plant parts will also be more available here providing important food to the phytophagous insects (which also form a part of peafowl's diet) as well as peafowl.

(iii) West Gir has many sources of perennial water which results in suitability of a large geographical area for peafowl. East lacks this and has only two rivers, thus reducing the carrying capacity of the region.

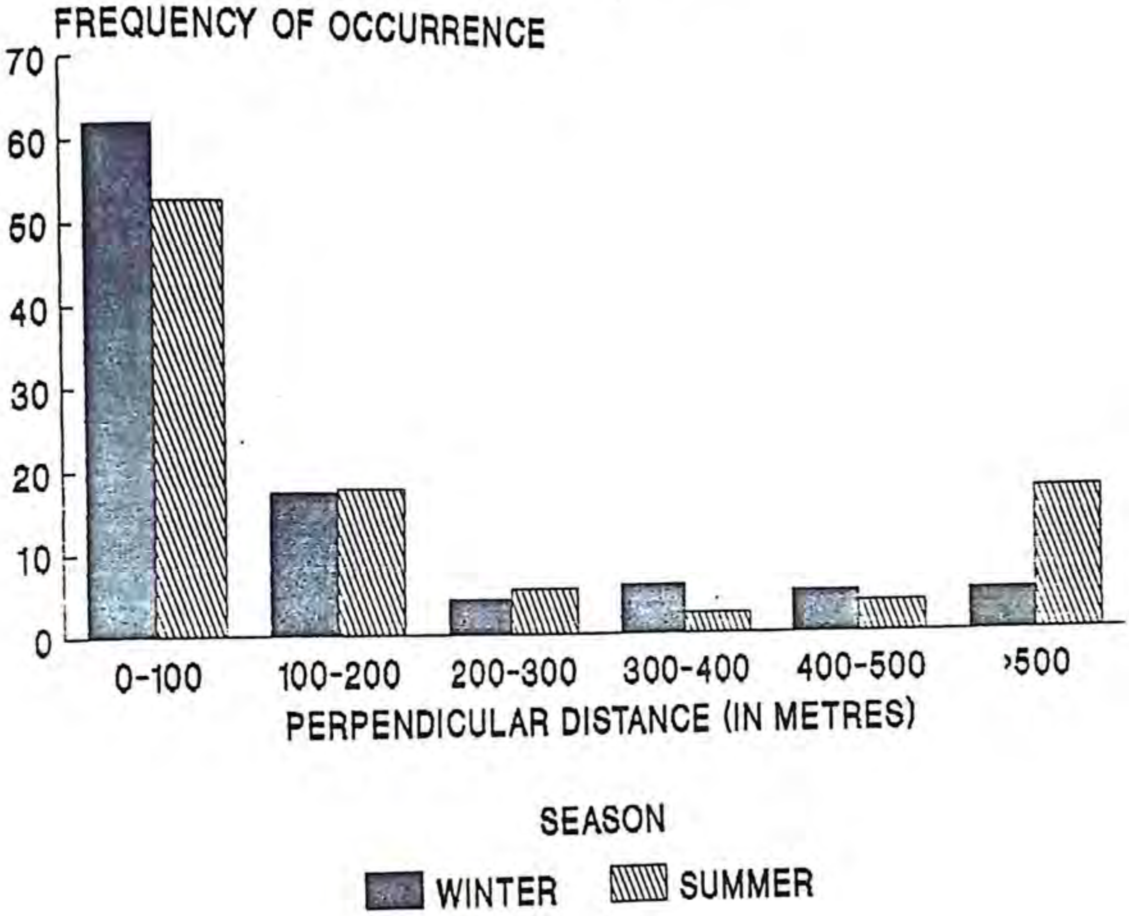
(iv) Due to evacuation of maldharis from Central Gir, buffalo grazing stopped. Grass height reaches nearly two metres due to lack of grazing. Changes also occurred in water availability as most of the water sources (such as dugwell) used by the maldharis were not maintained. Reduced availability of water coupled with tall grass might have affected the peafowl numbers here and a decrease could have resulted. Moreover, much of the N.P. (which is a major part of Central Gir) is hilly and rugged rendering it unsuitable for peafowl (see section 4.2.3).

(v) West Gir has the highest number of plant communities (10) resulting in a high degree of heterogeneity (in the number of habitats and not the changes/km.). This may be one reason for high density of peafowl there. Also, presence of cultivation in West should have inflated the density figures.

Johnsingh and Murali (1980) estimated peafowl densities (using total count method) to be from $85/km^2$ to $250/km^2$ in a rural agricultural landscape. The density figures for Central and East Gir are comparable, but figure for West Gir seems quite high as compared to these. High density of peafowl in Gir is vital because peafowl is an important buffer prey species (along with common langur) for large congeneric predators, lion (*Panthera leo persica*) and leopard (*Panthera pardus*) to coexist at high densities. Frequency of occurrence of peafowl and langur remains in the scats of leopard was 8 percent and 34 percent, whereas these two species occurred 1.6 percent and 4.7 percent times in lion scats (Ravi Chellam, pers. comm.). Also, out of the 11 species recorded as prey of leopard, langur comes second and peafowl fifth, whereas for lion these two species figure eighth and seventh respectively (Ravi Chellam, pers. comm.). This shows that prey size difference is an important factor in ecological separation of lion and leopard and peafowl falls in the small sized prey category (<25 kg), which is highly used by leopard, whereas lion uses larger prey (>50 kg) more. Peafowl also may be contributing significantly to the diet of lesser cats such as jungle cat (*Felis chaus*).

The differences in densities and congregation of sightings in a few segments of the transects indicate a clumped nature of peafowl's distribution in the Gir PA. The degree of clumping increases near water sources on all the transects. Water is a vital resource for peafowl as is apparent from their frequency of drinking (Ali & Ripley 1987; Pers. obs.). This explains the necessity for them to stay close to water. Figure-6 shows the distribution of peafowl sightings with respect to their distance from water. Nearly eighty percent (n=245) of these were within two hundred metres from water. Water however, is not a limiting factor

Fig-6 DISTANCE TO WATER FOR PEAFOWL SIGHTINGS (Sasan)



in riverine areas and therefore clumping should either be less or altogether absent in these areas. This exactly is the case and sightings on the riverine transect are fairly well distributed in all segments. Eighty eight percent of the major clumps (n=17) occurred in plant communities which were either used more than or according to their availability. Therefore, both the presence of water as well as food seem to exert a profound influence on the degree of clumping and ultimately the overall distribution pattern of peafowl in the Gir PA.

5.2 HABITAT SELECTION:

There are two principal questions that a researcher asks while studying habitat selection: (i) Why does a species select (a) particular habitat type(s) ? i.e. What are the factors influencing habitat selection by that species ? and (ii) Which are the cues used by a species to identify and select these habitats ?
I more specifically sought answers to the former question (as latter was not within the scope of this study). The major environmental factors that can influence habitat selection by an individual bird can be: structure of the habitat; food and water availability; morphology, physiology and anatomy of the individual; nesting, resting and roost site availability; presence/absence of competitors and/or predators. Therefore, my attempt will be to analyse the observed pattern of habitat use with reference to the afore mentioned parametres.

5.2.1 WEST GIR (SASAN) - The fact that RIP, CULT and DF were used more than their availability is probably suggestive of better resource status of these habitats as compared to other less used ones. Cultivation is naturally the most ideal habitat because it provides a perennial supply of food (in terms of crops, insects and other invertebrates) and water. This also ensures better survival of chicks. Wheat, groundnut and vegetables are the major food items available. Moreover, because of its presence in and/or adjacent to the forest makes this community even more preferred as the forest provides cover for escaping from predators, resting and roost sites. Nesting sites are available around the farmlands in hedges as well as inside the forest. Peafowl are not killed in this region by the farmers (there are exceptions to this) and they just drive away the birds intermittently. This provides the birds with the best opportunities of optimal habitat use in agriculture-forest mosaic areas.

Another highly used community is RIP. For peafowl, the most essential structural elements of the RIP are roost trees and resting sites. My observations on roost site and tree selection revealed that roosts are mainly confined to riverine areas thus making this a crucial habitat. Roost tree selection is discussed in detail later. Peafowls rest during the hot hours of the day. For this purpose they select the shade of dense shrubs or thick canopied trees. Out of the ten shrub/tree species used for resting (Appendix-2), five reached their highest abundance in RIP. The remaining five were also present in RIP in varying numbers. A very highly used shrub *Carissa* was quite dominant and the commonest understorey shrub in riverine areas. Due to these features, RIP was used extensively for resting. RIP has a low visibility (58 %) at a height of .45 metre thus providing good cover for chicks to stay concealed. Insect diversity can attain high levels at medium canopy cover (i.e. neither too low nor too high) levels. A rich interspersion of habitats at understorey level in forests is responsible for this (Gadagkar *et al.* 1991). This may apply to RIP which has an average canopy cover of thirty seven percent and rich understorey which provide a suitable habitat to a diverse insect fauna. Hill and Robertson (1988) stressed the importance of insects for ring necked pheasant (*Phasianus colchicus*) chicks. Peafowl chicks also may be requiring high amounts of insect diet in the early growth stage which can only be attained in communities such as RIP. Therefore, RIP becomes a crucial habitat for successful growth and survival of chicks. RIP provides good feeding grounds too as is apparent from table-10. A word of caution necessary here is that though grasshoppers were classed as a food item, it was not known whether all the species available are taken. Therefore, tables 10 and 11 may not reflect actual grasshopper availability, but only potential availability. As far as herbs and shrubs are concerned, these were all confirmed forage species.

DF was the third community which was used more than availability. DF interestingly had the highest average herb density (Table-1' of which a large proportion was formed by forage herbs such as *Cassia tora, Triumfetta, Achyranthes* (Table-10). It also had the highest proportion of forage shrub species out of the total shrub species available (Table-10). Eventhough DF had good food resources, there are reasons to believe that it was still not a preferred habitat. In RIP and CULT the number of females always exceeded the number of males. Moreover, young birds (chicks) were observed very frequently in RIP and CULT. The case was reversed for both (i.e. females:male ratio and chick sightings) in DF. With ring necked pheasants, it was suggested that there should be a difference in the dispersal nature of males and females, with

TABLE:10 FOOD AVAILABILITY IN DIFFERENT HABITATS (SASAN)

HABITAT	GRASSHOPPER/INSECT ABUNDANCE	LIZARDS	FORAGE HERBS(%)	FORAGE SHRUBS(%)
RIP	34	-	33.3	38.9
CULT	48	-	*	-
DF	15	2	44.4	55.5
TW	13	3	18.2	15.1
SCR	25	1	40.0	46.7
SAV	3	2	-	16.7
TMF	16	1	33.3	26.7
TA	27	1	40.7	38.9
TMF(H)	16	2	22.2	16.7
LB	27	1	16.7	-

Grasshopper/insect and lizard abundance is in a transect of 200x2 metres.

* In cultivation most of the times all herbs were forage herbs (crops).

females occupying the best habitats and males using the suboptimal or marginal (open) habitats (Hill and Robertson 1988). However, Bendell and Elliott (1966) showed that the selection of more open (and seemingly suboptimal) habitats by males essentially reflects the initiation of territory establishment in such areas. This is not the case with peafowl as adult males establish territories only during the breeding season which is from June to September (Hillgarth 1984). The number of adult as well as immature males was much higher in DF (with adult sex ratios of female:male being 100:212.5 and for immature birds sex ratios of 100:400). This leads one to believe that a higher use of DF by males might not necessarily be a result of its better resource status but of the dispersal nature of peafowl. It is also possible that adult males selct DF owing to its open nature and less undergrowth. They will have difficulty in taking off in a dense undergrowth habitat. An intensive and detailed study can bring out more facts.

It is very interesting that all the habitats that were used more than their available proportions, had water within 200 m. It is relevant to point out here that Green peafowl (*Pavo muticus*) also inhabits riverine areas- especially sand banks and open areas in the vicinity of water (Davison 1986; Hillgarth 1988). It later expanded into agricultural habitats but got exterminated locally in many parts of its range due to hunting (Davison 1986). Indian peafowl on the other hand received protection from humans and could establish in human created landscapes. However, it occurs near human dwellings even when hunted, which means only protection was not essential for their successful colonisation.

The two major teak forest types i.e. TMF and TA which cover extensive areas in West and Central Gir were used less than their available proportions. Both, TMF and TA have high average tree density (716/ha and 476/ha respectively). Dense tree growth could hamper flight and take off of these large, heavy bodied birds. Naturally, one would expect that these communities will be avoided. Both, TA and TMF had high canopy cover and litter which is a function of increasing tree density. Peafowl is predominantly a ground forager (Pers. obs.) and seeds (which are mainly eaten after they fall on the forest floor) contribute a sizable proportion of the diet during winter and summer (Fig-5). High litter accumulation due to teak leaves therefore may reduce the foraging efficiency. Similar findings have been documented by Cody (1968 in Cody 1981) for bobolink (*Dolichonyx oryzivorus*) which selects prairies with low litter accumulation in Minnesota. Both these communities had a low visibility and tall grass growth (Table-1). Peafowl's antipredatory strategy (except for chicks who are small and cryptically coloured) depends on the ability to detect predators. Tall grass and low visibility will seriously hamper their capability of detecting predators even with large groups. A combination of these structural features might therefore have resulted in proportionately less use of these habitats. Food availability in TMF and TA however was comparable to other more used habitats, which promoted their observed use (though less) inspite of unsuitable structural features. It is important to visualise that TMF and TA cover large areas in Gir PA and therefore though being used less, should be supporting a large number of Peafowl just due to their extent. Null habitats TMF(H) and LB had no sightings. This can be attributed to hilly terrain on which they were present, tall grass growth and low plant food availability (plants were more important because peafowl are mainly primary consumers: Fig-5) which synergistically might render exploiting of these communities uneconomical. Rest of the communities (TW, SCR & SAV) were used according to their availability. TW and SCR had good resource availability, but SAV was a poor quality habitat in terms of resource availability and other factors (Table-10). However, because of the less extent of SAV, even few sightings can show a high use. Moreover, as SAV occurs in low proportions, the chances that one sees an individual using this habitat for moving from one habitat to another are high. This may be the case here.

5.2.2 CENTRAL GIR (Chhodavdi) - PTW and TA emerged as two highly used habitats in Central Gir (Chhodavdi). These were relatively open habitats and were food resource rich. Moreover, most of the used areas in these communities were burnt patches, thus further supporting the conclusion regarding use of more open areas in Sasan. RIP was actually very highly used, but due to its poor representation on the transects it did not show that high intensity of use. SAV, TMF(H) were used less mainly because of their presence in the hilly parts. A few sightings which occurred in these habitats were found to be within 100 metres of water i.e. when hilly terrain started right from the river bank. Tall grass in these areas further rendered these communities unsuitable. TMF was used the least owing to similar reasons as in Sasan.

5.2.3 EAST GIR (Dodhi) - East Gir had only five major plant communities of which the RIP was not represented on the transects. TW was the most highly used habitat owing to a high availability of forage herbs especially *Cassia tora* and *Triumfetta*. It also had a high forage shrub (*Zizyphus mauritiana* and *Z. oenoplia*) abundance (Table-11). The fact that fifty five percent (n=18) of the young were encountered here and female to male ratio was 100:20 is in itself an indicator of the quality of TW. Nearly sixty eight percent (n=124) of the birds were seen in TW. AMF was the next highly used habitat. This community occurred in moist localities and also on seasonal stream banks. Thus, it was a parallel of mixed RIP association of West Gir which was highly used there. Very high forage shrub and insect (grasshoppers) abundance (Table - 11) might be the major reasons for a high use of this community. It also offered good concealment cover for chicks. SAV and AA were the least used habitats. Of the two, SAV was used more, which was surprising as it altogether lacked herb layer and due to its open-barren nature was not a good habitat for chicks. AA on the other hand had a higher abundance of forage herbs, shrubs and insects as well as lizards (Table-11). I am unable to explain this unusual pattern. But, if a poor quality habitat is between two better habitats, even the birds using this area for moving between two good habitats can distort the picture with a low intensity of sampling. Small data size did not permit further detailed analysis of seasonal differences or age and sex differences in habitat use for Central and East Gir.

On the whole, the habitat selection by peafowl was flexible. But, at the same time there were striking similarities in habitat selection in these three different areas. This similarity was reflected in the use of more open areas in the vicinity of water, avoidance of dense habitats and choice of food resource rich habitats in general.

5.2.4 STRUCTURAL FEATURES - Further analyses of some important variables yielded interesting information on their use. The structural aspects of vegetation are important because they can

TABLE:11 FOOD AVAILABILITY IN DIFFERENT HABITATS (DODHI)

HABITAT	GRASSHOPPER/INSECT ABUNDANCE	LIZARDS	FORAGE HERBS (%)	FORAGE SHRUBS (%)
TW	9	3	43.6	25.6
SAV	8	3	-	33.3
AA	16	4	30.5	25.0
AMF	35	-	25.0	41.7

For full forms of the habitats see Section:4.1

Grasshopper and lizard abundance is for a transect of 200x2 metres.

provide cues for habitat choice as well as modify the ways birds exploit resources (Roth 1980). Blue grouse (*Dendragapus obscurus*) also respond to the structure of habitat (i.e. denseness/openness) and settle in more open habitats (Bendell & Elliott 1966). Even in the case of Western tragopan (*Tragopan melanocephalus*) structural components influenced use and selection of the habitat (Islam & Crawford 1986). Use of 0-100 trees/ha density class more than its availability is suggestive of peafowl's preference for open habitats. Very dense areas i.e. tree density > 700/ha were used less than their availability. Use of most shrub density categories according to availability indicates that it may not be affecting peafowl distribution significantly. However, less use of higher shrub classes during both the seasons is suggestive of avoidance of the forests with dense undergrowth. Less use of tall grass areas indicates that it hampers their movement and visibility. It also might reflect the scarcity of other food items such as herbs due to profuse grass growth. Low grass areas (<15 cm) were used more in both the seasons as they provide the best visibility. Low herb height is also used more than availability probably due to the same reasons as for grass during winter. In summer however, tall herb cover (45-60 cm) was used more. The reason for this may be the use of cover. In summer, when much of the undergrowth dies off, peafowl may use areas with tall herb cover, which unlike grass does not hamper visibility considerably (because of scattered nature of herbs as compared to grass clumps). Adult peafowl are 0.75 metre tall and therefore 45-60 cm herb category will not really affect their visibility. Instead, very tall herb cover (>60 cm) might have been used less because of the fact that it hampers visibility. As discussed earlier (section 4.2.3 & 5.2.1), negotiation of hilly

5.2.6 SEX AND AGE DIFFERENCES IN HABITAT USE: I hypothesized that sexes will tend to differ in their habitat use, but the results showed they did not. Male and female ring necked pheasants (*Phasianus colchicus*) differ in their habitat use, with females using woodlands more and males using cropland hedges and open areas more (Hill and Robertson 1988). Bendell and Elliott (1966) on the other hand suggest that male and female Blue grouse do not show such differences in habitat choice i.e. both the sexes use open areas. Though, my results were not sensitive to the statistical test performed, it does not rule out the possibilities of such a difference. A more detailed study of individual selection and dispersal mechanism can bring out more facts. The number of males and females varied greatly between the three preferred habitats. RIP and CULT had a higher number of females suggesting that these are better habitats for successful survival and reproduction. However, DF had a higher number of males, the probable reasons for which have been discussed earlier. Chicks feeding with mothers in cultivation always kept to within 25 metres from the hedge. This is an antipredatory strategy against raptors such as Crested Hawk Eagle (*Spizaetus* spp.) which are known to kill even adult males with trains (Johnsingh 1983).

5.2.7 GROUP SIZE DIFFERENCES ACROSS HABITATS: The significant difference in group size between habitats is suggestive of either (i) A difference in resource availability or (ii) Antipredatory strategy or probably both. A high frequency of encounter for groups as (also shown in results) compared to solitary individuals partly reflects the antipredatory strategy of detecting the predator with increased vigilance. Exceptionally large group sizes (>10 birds) were encountered in RIP, CULT, SCR, TW and TMF, of which seventy five percent occurred in RIP and CULT. This probably explains the relationship of group size with high food availability. RIP and CULT were the richest habitats as far as food was concerned. Larger group size in CULT offered an additional advantage of better predator detection capabilities. In more open habitats, such as TW and SCR, increased vigilance seems to be the cause of larger group sizes. Thus, the observed pattern of group size differences across the habitats may be attributed to a combination of abundant food and improved vigilance.

5.2.8 ACTIVITY AND HABITAT USE: It is very important to consider habitat selection based on the activities of birds. All the plant community types in Sasan, except null habitats were used for foraging. However, for resting, denser communities such as RIP and TMF were used extensively. Roosting was confined almost exclusively to RIP. In East Gir, all four communities were used for foraging, but resting was mostly restricted to RIP and TW. Therefore, it is evident that RIP is the most crucial habitat for all activities, whereas other habitats are used mainly for foraging.

5.3 ROOST SITE AND TREE SELECTION:

Many hypotheses have been put forward to explain avian roosting behaviour. These have been reviewed by Gadgil and Ali (1974). The four major hypotheses include information centre hypothesis, population density assessment hypothesis, heat loss prevention and reduced risk of predation (See Gadgil & Ali 1974 for a detailed account). However, these are generally applied to communal roosters. Indian peafowl is not a strict communal rooster, but I will try to find relevance between my findings and these hypotheses. The five most striking features of peafowl roost tree use are summarised below:

(i) Trees on very steep slopes received the highest degree of usage.

(ii) There was a significant difference between the use of trees with and without climber (mostly *Combretum* spp.) thickets in the canopy. The trees with thickets were used proportionately more than availability.

(iii) Significant difference existed between the use of trees with and without thorny thickets (of *Carissa*, *Zizyphus oenoplia*) in the undergrowth. Trees with thickets were used more.

(iv) Trees with a height of >16 m were used more.

(v) Trees with a first branch height of 8-10 m were highly used followed by the lower height categories in a decreasing order.

All the above features indicate that while selecting a roost tree, the most important aspect is of reducing the risk of predation. In Gallinaceous birds, predation is a major population regulatory mechanism (Lack 1954 in Berwick 1974; Hill & Robertson 1988) and therefore it is likely to influence habitat selection significantly. Selection of tall trees on steep slopes with thorny undergrowth and climber thickets in the canopy is obviously an antipredatory strategy against mammalian predators such as leopard and jungle cat which can climb trees with ease. Trees with such features are available only in riverine areas and therefore RIP becomes all the more important for peafowl in the Gir PA. The roost sites were generally located at the confluence of a small stream with a larger one or a river. This region is normally difficult to approach and offers the peafowl greater safety.

Roost tree information provided an opportunity to address the old question of 'role of structure or floristics' in habitat selection. It seems very likely that the most important feature for roost tree selection is the physical characteristic i.e. structure of a habitat/tree. Any tree for that matter which satisfies the structural requirements should be selected by birds. Structure, undoubtedly appears to be the first step in selection, where peafowl select RIP to roost. But, it is possible that only certain tree species possess these structural attributes on which the choice depends. For example, if only 2-3 species can attain a height of >15 m or if climber thickets are associated with some particular species more than others, then choice should be made at the species level i.e. floristics. Peafowl are large bodied birds and require strong horizontal branches in the top canopy or at the extremities for roosting. This requirement cannot be met with by all the riverine tree species. It is obvious that choice will be at a species level for that structure. The situation seems to be one of a hierarchial selection as described by Svardson (1949), Hilden (1965 in Cody 1985) and Wiens (1985). The first step may be selection for structure and species will follow in the process. However, this is just a logical speculation and no experimental evidence is available to test it. Peafowl in semi-urban and rural landscapes use surprising substrates as roost sites. One such substrate is high tension electric poles. Palmyra trees (*Borassus flabellifer*) are used commonly in the Southern districts of Tamilnadu (A.J.T. Johnsingh, pers. comm.). This further leads one to believe that roost tree selection is also flexible. It is the structure which is the unit of selection at a broad scale, but at a finer scale, the selection can be for species.

One more feature which influences roost site selection is the occupancy of trees by other species. It was observed in ten cases that peafowl did not use particular trees (even when they were ideal for roosting) because common langurs (*Presbytis entellus*) were roosting there. This brings out the question of competition between taxa for a limited resource. Langurs are also distributed along the riverine areas in Gir (Joslin 1973) and they too roost in RIP. However, the magnitude of such potential competition might not be significant. It could not be determined whether there exists any difference between sexes and age-classes in roost tree selection. Males with long trains used dry,leafless trees but it could not be confirmed whether all the males get these kind of trees. Only one roost tree used by chicks was identified. It was quite short (ca 10 m) as compared to the general height categories selected by adults, but had extensive thorny thickets in the undergrowth. With the exception of 4 trees (out of 128), no roost tree was close to the roads, which might be to avoid the disturbance caused by vehicles.

5.4 ANTHROPOGENIC PRACTICES AND HABITAT CHOICE:

5.4.1 GRAZING - Grazing is a major factor which maintains a low grass height in all habitats. Low grass areas are used more by peafowl and therefore grazing seems to be beneficial for the birds. Trampling of the vegetation and creation of paths in denser regions by livestock allows peafowl to use these areas for foraging.

5.4.2 FIRE - Controlled roadside burns and fireline creation remove the ground vegetation and provide better conditions for peafowl with increased openness of the habitats. This is especially true for the N.P. where very tall grass greatly reduces the area available to peafowl for foraging. Fire also exposes the fallen seeds on the ground which can then be taken by peafowl very easily. Bendell and Elliott (1966) also observed an increase in the densities of Blue grouse after fire. However, uncontrolled forest fires burn a substantial amount of undergrowth. This will affect food availability in terms of vegetable matter, fruits and arthropods. Species such as *Zizyphus mauritiana*, *Z. oenoplia*, *Carissa* and *Acacia* spp. which are important for food as well as resting get affected seriously due to their low crowns. These uncontrolled fires therefore are harmful to peafowl.

5.4.3 HUMAN HABITATION - Peafowl numbers were high in cultivation as well as near the 'ness' sites. Perennial water supply was assured near human habitations. Moreover, 'nesses' provided open foraging areas where large groups can be safe from predators. Major food items of peafowl in Gir (e.g. *Cassia tora*, *Achyranthes aspera*, *Triumfetta* spp., *Calotropis procera*) which are mainly weeds, abound near human dwellings. Resting, nesting and roosting sites are also available. Thus, ultimately peafowl benefit from human coexistence. However, it should be remembered that hunting could decimate and even cause local extinction of this species. Another threat is the excessive use of pesticides in croplands which can reduce the arthropod fauna (however, which group of arthropods gets affected will also be important), affect the birds directly as they eat the crops and cause physiological changes that can reduce productivity (Hill & Robertson 1988).

5.4.4 WATERHOLES - Instead of creating artificial waterholes, rejuvenating the already existing (but unused for long time) waterholes made by maldharis will be more desirable for not just peafowl, but most of the fauna in the Gir PA.

5.5 HABITAT SELECTION: EVOLUTIONARY AND ECOLOGICAL SYNTHESIS:

The observed pattern of habitat selection by peafowl will be clearer and have more relevance when viewed in the context of the evolutionary and ecological background of peafowl. Peafowl are the final lineage of the peacock pheasants (Geist 1977) and have spread from the tropical climax forests of Southeast Asia to their present range. Primitive members of the same ancestral stock who still have retained their forest homes are monogamous, sexually alike (or weakly dimorphic) and more aggressive (Geist 1977). But, *Pavo* (Peafowls) freed themselves from the climax food to exploit the highly productive ecotones between forest and water (Geist 1977). This is corroborated by the fact that peafowl in the Gir PA were inextricably linked with the presence of water as well as open forest. Geist (1977) puts peafowl in the category of 'grotesque giants' who are large-scale opportunists. As peafowl invaded xeric and more open habitats, their sexual dimorphism became more pronounced (even when compared to its cousin *Pavo muticus* in which males and females are alike except for the train of the male), polygyny evolved and the aggessiveness between individuals was reduced. All these features tend to support the findings that peafowl preferred to use more open areas in Gir. When a species moves from a habitat with plentiful cover and adapts to one poorer in concealment cover, gregariousness becomes a means of reducing predation (Wilson 1975 in Geist 1977). This is exactly the case with peafowl in which grouping of individuals in open habitats appears to be related to enhanced vigilance. Open habitats with low tree density and low grass height tended to be associated with human dwellings. Moreover, human habitation ensured the availability of water too. These factors led to the colonisation of man created landscapes by peafowl during the course of dispersal.

Peafowl are believed to be generalists, but a high degree of selection observed in the Gir PA poses important questions regarding the word 'generalist'. It is felt that even the so-called generalists can be selective at one or the other scale. Adaptiveness ,and tolerance are often confused with each other (Davison 1986). Peafowl's use of man created landscapes may not necessarily be due to adaptiveness (i.e. involving a change in gene frequencies). It is very much possible that the cues used by peafowl are not affected by man induced changes and so selection of such landscapes is normal for the bird.

Svardson (1949) and Hilden (1965 in Cody 1985) have viewed habitat selection as a two stage process. In the first step individuals assess the general features of the landscape and then in the next stage respond to specific features in determining where to settle (Wiens 1985). For peafowl, presence of water, undulating or flat terrain and denseness or openness of the habitat may be acting as cues for selection. Food availability and the presence of predators also could influence the habitat choice. There is some indication of a hierarchial selection operating for roost tree selection. However, evidence does not exist to make any conclusive remarks.

Extremely high population densities result in intraspecific competition. This is ultimately manifested by characteristics such as unusual nest sites (Svardson 1949). Indian peafowl nests have been seen on roofs of houses, in other birds' (such as storks) nests and cropland hedges. Peafowl have also been observed roosting on electric poles. All these unusual nest and roost sites may be indicative of a high population density, resulting in competition for crucial resources. However, possibility of extreme alterations in the landscape leading to the use of such sites (which are the only available ones) cannot be ruled out. Habitats which are less suitable (in terms of their food resources), may be tolerable if the population densities are lower than in prime habitats (Fretwell & Lucas 1969 in Cody 1985). Many habitats which are potentially poor in quality may still be used at low densities. Dispersing and establishing individuals of the population might be getting pushed into these habitats. The overall distribution suggests that females and a few adult males occupy the best habitats, whereas dispersing juvenile males and other adult males might be forced to occupy the suboptimal habitats.

5.6 CONCLUSIONS:

(i) Distribution of peafowl is uneven (i.e. clumped) in the Gir PA and the degree of clumping varies.

(ii) Clumping increases near water sources and resource rich plant communities.

(iii) West Gir has the highest density of peafowl followed by Central and East Gir.

(iv) RIP, CULT and DF were used more than their availability as these were in vicinity of water, rich in food resource and had vital structural features (only RIP) such as resting and roosting sites.

(v) TMF and TA were used less than their availability due to the presence of unfavourable structural features such as high tree density, tall grass and high accumulation of leaf litter.

(vi) Rest of the communities (TW, SAV & SCR) were used according to their availability. TMF(H) and LB were null habitats where no peafowl were sighted.

(vii) Undulating terrain was used more whereas flat areas were used in proportion to availability and hilly regions were avoided.

(viii) There was no marked seasonal difference in habitat use.

(ix) Sexes did not differ significantly in their habitat selection.

(x) Use of concealment cover was common antipredatory strategy used by peafowl, but for detecting predators, visibility (achieved by increased group size) was most crucial. Use of open areas therefore was possible due to gregariousness.

(xi) In general, more open areas in vicinity of water were used more by all age and sex classes.

(xii) There were significant differences in group size across various habitats. Most of the sightings were of groups. Large group sizes are believed to be a function of both- resource abundance and increased vigilance.

(xiii) Roost sites were mainly confined to RIP. Twenty one species of trees were used as roosts. Tall trees on steep river banks with climber thickets in the canopy and thorny thickets in the undergrowth received the highest use. Roosting, clearly was an antipredatory strategy against mammalian predators such as leopard and jungle cat. Selection of roost trees may involve using cues such as structure and floristics in a hierarchial fashion.

(xiv) Buffalo grazing was beneficial to peafowl as it maintained a low grass height (<15 cm) in which movement is easy and predator detection efficiency is high. Small scale and controlled fires created favourable conditions, but uncontrolled fires render the habitat poorer and thus are not favourable for peafowl. Peafowl numbers were high around maldhari settlements and cultivation, but close to human dwellings where hunting is widespread, peafowl numbers could be low. Even local extinction could result in such areas.

This study has probably generated more questions than answering. Despite of its shortcomings, it has added some information to the existing knowledge on Indian peafowl. These conclusions are by no means an end of a study. Instead, they are intended to provide some baseline data to carry out further research on this least studied species.

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* originals not seen.

APPENDIX I

FOOD ITEMS OF PEAFOWL :

SPECIES	PART EATEN
1. *Zizyphus mauritiana*	Fruits (Ripe)
2. *Z. oenoplia*	Fruits (Ripe)
3. *Cassia tora*	Seeds (dry)
4. *Achyranthes aspera*	Seeds (dry, green ?)
5. *Peristrophe*	Leaves & Shoots ?
6. *Triumfetta rotundifolia*	Leaves & Fruits
7. *Cocculus hirsutus*	Fruits (Ripe)
8. *Phaseolus* spp.	Seeds
9. Simed*	Seeds
10. *Calotropis procera*	Leaves, flowers
11. *Butea monosperma*	Flowers, fresh unripe pods
12. *Acacia nilotica*	Seeds
13. *A. catechu*	Seeds
14. *A. ferruginea*	Seeds
15. *Capparis sepiaria*	Young leaves
16. *Ageratum conyzoides*	Shoots & leaves
17. *Sida* spp. ?	Leaves & shoots ?
18. Grass *(spp. - 3 or more)	Seeds, green leaves
19. *Michinia* ?	Seeds
20. *Ficus bengalensis*	Fruits (ripe)
21. *Ficus glomerata*	Fruits (ripe)
22. Grasshopper	Whole
23. Scorpian	Whole (small - 0.5 cm)
24. Beetle ?	Whole
25. Larvae	-

* scientific name not known.

APPENDIX II

SPECIES USED FOR RESTING BY PEAFOWL :

1. *Carissa opaca*
2. *Zizyphus oenoplia*
3. *Capparis sepiaria*
4. *Aegle marmelos*
5. *Pongamia pinnata*
6. *Butea monosperma*
7. *Ficus bengalensis*
8. *Syzygium* spp.
9. *Zizyphus mauritiana*
10. *Acacia nilotica*

APPENDIX III

LIST OF TREE SPECIES USED FOR ROOSTING BY PEAFOWL

1. *Holoptelia integrifolia*
2. *Tectona grandis*
3. *Pongamia pinnata*
4. *Syzygium rubicunda*
5. *Tamarindus indica*
6. *Diospyros melanoxylon*
7. *Terminalia bellerica*
8. *T. tomentosa*
9. *Manilkara hexandra*
10. *Syzygium cumini*
11. *Ficus glomerata*
12. *F. bengalensis*
13. *Miliusa tomentosa*
14. *Mitragyna parviflora*
15. *Garuga pinnata*
16. *Sterculia urens*
17. *Acacia senegal*
18. *Anogeissus latifolia*
19. *Phoenix sylvestris*
20. *Dendrocalamus strictus*
21. *Sapindus emarginatus*

APPENDIX IV

SALIENT FEATURES OF THE TRANSECTS

TRANSECT NUMBER	LENGTH (IN km)	TERRAIN FEATURES	PLANT COMMUNITIES	SPATIAL HETEROGENEITY
SASAN (WEST GIR - SANCTUARY)				
T-1	2.1	FLAT & UNDULATING	TMF,TA,TW, RIP	5.7
T-2	0.8	FLAT	RIP, DF, TMF, SCR	6.2
T-3	1.4	FLAT & HILLY	SCR,DF,TMF, TA, TMF(H)	3.6
T-4	1.0	UNDULATING & HILLY	SCR,SAV,TW, TA,LB	7.0
T-5	1.5	UNDULATING & HILLY	CULT,DF,TA, TMF,SAV,TW, TMF(H)	8.0
CHHODAVDI (CENTRAL GIR - N.P.)				
T-1	1.1	UNDULATING & HILLY	PTW,TMF(H), RIP,TMF,TA, SAV	9.1
T-2	0.6	UNDULATING & FLAT	TA,TMF	6.7
T-3	0.5	UNDULATING & HILLY	TMF,TMF(H), TA	4.0
DODHI (EAST GIR - SANCTUARY)				
T-1	1.5	UNDULATING & FLAT	TW,SAV,AA	5.3
T-2	1.8	FLAT & UNDULATING	SAV,AMF,AA, TW	7.2

* SPATIAL HETEROGENEITY= NUMBER OF CHANGES IN PLANT COMMUNITIES/KM.