ECOLOGICAL SEPARATION OF FOUR SYMPATRIC CARNIVORES IN KEOLADEO GHANA NATIONAL PARK, BHARATPUR, RAJASTHAN, INDIA.

DISSERTATION SUBMITTED TO THE SAURASHTRA UNIVERSITY, RAJKOT IN PARTIAL FULFILLMENT OF MASTER'S DEGREE IN WILDLIFE SCIENCE (1988-89)

By Shomita Mukherjee

Supervised by
Dr. A.J.T. Johnsingh, Associate Professor,
Wildlife Institute of India, Dehra Dun.

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CERTIFICATE

This is to certify that Ms. Shomita Mukherjee has carried out an original piece of research in partial fulfillment of her M.Sc (Wildlife) degree of the Saurashtra University, Rajkot. The topic of dissertation is "Ecological separation of four sympatric carnivores in Keoladeo Ghana National Park". The investigations were carried out at the Wildlife Institute of India, Dehradun under my supervision from May to December 1989. I hereby certify that this work has not been submitted for any degree of any university.

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Associate Professor

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SUMMARY

The study conducted from 5th May 1989 to 9th October 1989, covering summer and monsoon looked at the ecological separation of four sympatric carnivores in Keoladeo National Park, Bharatpur, Rajasthan. The four carnivores were - Jungle cat (Felis chaus), Fishing cat (Felis viverrina), Jackal (Canis aureus) and Otter (Lutra perspicillata).

Objectives of the study were to determine differences in dietary composition, habitat occupance and time of activity as well as to try out methods for studying sympatric lesser carnivores.

Five methods were tried out to obtain these objectives. Line transects and searches during mornings and nights were used to collect data on prey abundance, location of carnivores and their time of activity. Scats were collected and analysed to determine dietary composition and see how they differed among jackal, fishing cat and jungle cat. Otter spraints were not found.

The following conclusions are made.

Although some amount of overlap is evident an overall difference in habitat use, time of activity and dietary composition is seen. Jackals and jungle cats are habitat generalists but dietary specialists. The fishing cat and otter are habitat as well as dietary specialists. Jungle cat and fishing cat are largely nocturnal but the jackal and otter are active throughout the day. Behavioural observations added to the results obtained from the other methods. The methods however were found unsuitable for studying lesser carnivores.

ACKNOWLEDGEMENTS

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I am gratetul to Shri M.P.Aggarwal for typing the thesis, to Vandana Sabharwal for drawing the tables, and most of all, to Felis chaus and Felis viverrina for showing up and making this dissertation possible !

CHAPTER - I

INTRODUCTION

For sympatric species to coexist in an area, resource partitioning should not allow competitive exclusion. By occupying separate niches sympatric species avoid such competition (Gause 1934).

Resource partitioning by carnivores have drawn the attention of ecologists. Large carnivores in South Asia have been studied by : Schaller (1972), Johnsingh (1983) and Rice (1986). On lesser carnivores there are numerous studies eg., Major and Sherburne (1987), Waser (1980), but none in India. At least forty three species of lesser carnivores occur in India (Jonnsingh 1986) and any protected area would have more than three lesser carnivores. Inspite of this there is not a single study on the ecology of these species which examines niche occupance or resource partitioning.

Keoladeo Ghana National Park (29 km^2) primarily a protected area for waterfowl also has several lesser carnivores. This study was undertaken to examine niche separation among four of these species - the jungle cat (Felis chaus) the fishing cat (Felis viverrina), the golden backed jackal (Canis aureus) and the smooth Indian otter (Lutra perspicillata). All are of the same weight class, 6-12 kg.

1.1 JUSTIFICATION

The study has potential justifications. Basic ecological data on these species from India are lacking. Important biological information could be obtained on all four species by

studying their activity patterns habitat occupance and dietary trends.

The fishing cat is a Schedule-I animal of the Indian Wildlife Act (critically protected) (1972) and so information on this cat would be of value to management.

Keoladeo Ghana was selected as the study area for the following three reasons :

1. The Park has no large carnivores and so was a safe place for me to carry out the study on foot as at least two of the four species (Jungle cat and fishing cat) are nocturnal.
2. Discussions with several biologists suggested that the populations of Jungle cat, fishing cat and jackals in this Park are high (Johnsingh, Chundawat pers. commun). This was supported by the figures given in the B.N.H.S. Ecological Report (1985) for the Park. My preliminary visit to the park in Nov. 1988 gave me confidence that I could do the work here.
3. Secondary information on the Park was available from studies conducted by the Bombay Natural History Society's, Ecology team at Bharatpur and for vegetation, the French Institute at Pondicherry.

1.2 REVIEW OF LITERATURE

The Golden Jackal (Canis aureus)

Basic information on the morphology, races and distribution of the species is given by Prater (1980). Jackals weigh between 8 and 11 kgs (Prater 1980). They are social animals sometimes found in groups of 20 or more individuals (Macdonald 1979) but

more often in pairs. Like other canids, jackals are territorial, and packs and pairs share in defending their territory (Schaller 1967, Wyman 1967, Eaton 1969, Van Lawick and Van Lawick Goodall 1970, Golani and Keller 1975). Territories are demarcated by scent (urine) (Van Lawick and Van Lawick Goodall 1970), midden formations (Macdonald 1970) and vocalisation (howling) (Mohelman 1980). Jackals are most active during dusk and retire at dawn. Although carnivorous, their diet includes fruits and other vegetable matter, and when close to agricultural lands are known to raid sugarcane fields and melon patches (Prater 1980). They often scavenge on kills of larger predators and on carcasses. However pack hunting on small deer and antelope is not uncommon. Other prey species taken by the jackals are insects, lizards, rodents and small birds (Prater 1980, Rice 1986).

Pups are born at any time of the year in dens, which are normally large holes in the ground, drains or some natural shelter (Prater 1980).

The Fishing Cat (Felis viverrina Bennett)

This medium sized cat is stockily built, with short legs and weighs around 13 kgs. Due to its dependence on water, its range although wide is discontinuous. Its range is restricted to the Asian continent, from India to China and south to Java, Taiwan, Sind (Pakistan), Bangladesh and Sri Lanka (Ricciuti 1979 , Prater 1980). It lives in or near heavy jungle, scrub, grass swamps, tidal creeks, reed beds, mangrove swamps and deltas. As its name suggests a major portion of its diet is fish which it scoops out of the water with its forepaw without entering the water in

pursuit of the prey (Prater 1980). Its diet also includes other animals such as crabs, toads, frogs, birds; and they readily kill calves, goats, dogs, snakes and any animal that it can capture (Ricciuti 1979; Prater 1980). It apparently does not have a fixed breeding season, litter size is two (Daniel 1987).

The Jungle cat (Felis chaus Guldenstaedt)

Smaller than the Fishing cat, the jungle cat weighs between 5 and 9 kgs. It ranges from Iran to the Indian subcontinent, Sri Lanka, through Burma to Indo China (Ricciuti 1979, Prater, 1980, Daniel 1987). In India it is among the most widely distributed and common of the lesser cat species, inhabiting dense forests, grasslands, swamps and reed beds and on occasions taking up residence in old abandoned buildings (Prater 1980).

It hunts mostly in the mornings and evenings before and after sunset, on small mammals, birds, frogs, insects and sometimes animals much larger than itself. It is known to raid poultry when found in the vicinity of human dwellings (Daniel 1987, Prater 1980, Ricciuti 1979).

In south Central Asia, mating seems to take place late in winter and early in spring. Gestation period is similar to that of domestic cats being slightly over two months. Female jungle cats may bear upto 6 young at a time in dens which are usually abandoned burrows. However, usual litter size is three (Ricciutti 1979, Prater 1980). It is interesting to note that this species, along with the African wild cat (Felis sylvestris lybica) being domesticated by the ancient Egyptians is probably one of the ancestors of certain domestic breeds today (Sayer 1977).

The smooth Indian otter (Lutra perspicillata)

Larger than the common otter, the smooth Indian otter weighs between 7 and 11 kgs. In India it has a wide distribution, from the Himalayas to the extreme south. It is also found in Burma, Indo-China and Malaya. Although seemingly dependent on water, in drier parts of its range, it is known to enter jungles in pursuit of prey. In other areas it lives in lakes, streams, large tanks and creeks, catching fish, crabs etc. Group fishing has been recorded in this species. When alarmed they let out a sharp whistle. Breeding habits of this otter are unknown. Young are born early in the year (Prater 1980).

1.3 HYPOTHESIS

The hypotheses to be tested in this study is that the four species of lesser carnivores have sufficient niche separation to avoid competition. This is broken down in three components :

H_1 - The four species differ in their occupance of various habitats

H_2 - The four species differ in their time of activity

H_3 - The four species differ in dietary composition

1.4 OBJECTIVES

The study had several objectives :

1. To test the 3 hypotheses with data from the field.
2. To develop methods for studying and estimating densities of lesser carnivores in Indian conditions.

3. To obtain information on the basic behaviour and general natural history of the four little known species of lesser carnivores found within the Park.

This introduction is followed by Chapters on study area, methods, results, discussion and conclusions.

CHAPTER - II

STUDY AREA

2.1 LOCATION

Keoladeo Ghana National Park is located in the Bharatpur district of Rajasthan, between 27^0 7.6' and 27^0 12.2'N latitude and 79^0 29.5' and 77^0 33.9'E longitude, 2 kms. S.E. of Bharatpur city. It is surrounded on all sides by 14 villages and agricultural land. A masonary wall with barbed wire on the top protects the Park from the surroundings (B.N.H.S. , 1986).

2.2 AREA AND TOPOGRAPHY

The area of the Park is 29 km^2. It is flat with a gentle slope forming a depression in the centre. This depression forms the aquatic area which is 8.5 sq.km. The average elevation of the area is 174 metres (B.N.H.S. 1986).

2.3 CLIMATE

The climatic conditions in Bharatpur are extreme as annual temperature varies from a minimum of 1^0C in winter to a maximum of 50^0C in summer (B.N.H.S. 1986). "The mean minimum temperature between 1982-1985 was 6^0C as recorded in January 1984 and February 1985. The mean maximum was 48^0C in May 1984" (B.N.H.S. 1985). Annual rainfall ranges from 500 to 1000 mm.

2.4 FAUNA

Keoladeo Ghana National Park is chiefly managed for the numerous species of aquatic birds, raptors and land birds. The following summary is adapted from the B.N.H.S. Report, 1985. A major portion of the Park being wetlands, numerous species of

aquatic birds are found here. Seventy four aquatic bird species, twenty three species of raptors and 101 species of land birds have been recorded in the Park.

Thirty six species of fish have also been recorded.

Among the reptiles turtles, pythons and monitor lizard are prominent.

The mammalian fauna include :

Rodents : Porcupine (Hystrix indica) several species of mice, Five striped palm squirel (Funambulus pennanti).

Lagomorphs : Rufous tailed hare (Lepus nigricollis ruficaudatus).

Wild ungulates : Nilgai (Boselaphus tragocamelus), Blackbuck (Antilope cervicapra), Sambar (Cervus unicolor), Cheetal (Axis axis), and Wild boar (Sus scrofa). Feral cattle are seen in large numbers.

Carnivores : Striped hyena (Hyaena hyaena) Small Indian mongoose (Herpestes auropunctatus), Common mongoose (Herpestes edwardsi), Toddy cat (Paradoxurus hermaphroditus), Smooth Indian otter (Lutra perspicillata), Golden backed jackal (Canis aureus), Jungle cat (Felis chaus) and Fishing Cat (Felis viverrina), Rhesus macaque (Macaca mulatta) is the only primate recorded. Several species of bats are also recorded.

2.5 VEGETATION

Gaussen et al (1978) has described the vegetation of the Keoladeo National Park as "dry deciduous forest belonging generally to the Acacia catechu - Anogeissus pendula series".

According to Meher-Homji et al (1978), reduction of tree cover due to cutting and lopping brought about changes in the

vegetation. This resulted in degradation, with arid-zone species of western Rajasthan replacing the original A. catechu, A. pendula forests. The arid zone species commonly seen in the Park are : Prosopis cineraria, Capparis decidua, Salvadora oleoides, S. persica and Clerodendrum phlomoides. (Perennou and Ramesh 1987).

A finer classification of the vegetation types of the Park has been made by the French Institute of Pondicherry and the B.N.H.S. ecological team at Bharatpur (Perennou and Ramesh 1987). A description of the four habitats follows .

I classified the vegetation into four broad categories : (Fig. 1.)

1. Wetlands
2. Short grasslands
3. Tall grasslands
4. Mixed forests

2.5.1 Wetlands

Aquatic and marshy areas including canals come under this category.

The wetlands, being a natural and man enhanced depression get flooded every monsoon. Apart from rain water, the wetlands receive water from a dam - the Ajan bund located just outside the Park. The Ghana Canal carries the water into the Park.

For management purposes, the entire Park is divided into a number of blocks (Fig. 2). Blocks E,D,L and LW form a major portion of the wetlands. Earthern bunds form the boundary of each block. Sluice gates to regulate water flow are located at

strategic points in the wetlands and canals. Since the wetlands are managed for the various species of migrant and residential birds, the blocks are filled according to the requirements of the different bird species.

Throughout winter, water is present in the wetlands, drying up gradually until summer, when nearly the entire wetlands are dry (PLATE 1). Only a few pools of water remain. These water bodies are mainly deep depressions like the canals and the small lakes. In dry years (eg., 1986-87), the wetland is devoid of water even during winter (Perennou and Ramesh 1987).

The chief vegetation found in the wetlands are the grasses Paspalum distichum which is the dominant species, and Erianthus procerus found at the edge of the wetlands. Sedges Scirpus spp. and Cyperus spp. are also found in the marshy areas outside the major wetland blocks. Other species are Ipomea aquatica and Acacia nilotica trees. These were planted for the colonial water birds to nest from 1950's and early 1960's. A few Prospis cineraria trees are also scattered in the wetlands (Perennou and Ramesh 1987).

2.5.2 Short grasslands

Blocks M, K and J form the short grasslands (Fig. 2). The short grasslands are characterised by a continuous grass cover. The grass species are varied and are found in associations with tree species. The height of the grass ranges from 20 to 200 cm differing with species, (Perennou and Ramesh 1987) Grass cover increase during and after the monsoon. The different grass

species found in the short grasslands are : Sporobolus spp. forming a large portion of the short grasslands, followed by Desmostachya bipinnata, Cynodon dactylon and scattered Vetiveria zizanioides (Perennou and Ramesh 1987). The tree and shrub species in the short grasslands are Acacia nilotica, Mytragyna parviflora Dichrostachys cineraria, Zizyphus mauritiana, Prosopis juliflora, Salvadora persica, S. oleoides and Syzygium cumini (Perennou and Ramesh 1987).

2.5.3 Tall grasslands

Blocks F, G and H constitute this habitat (Fig. 2). The Chicksana canal flows through block H. Like the short grasslands, there is continuous grass cover but as its name suggests the major grass species - Vetiveria zizanioides found here grows > 2 m in height. Fewer grass species occur here than in the short grasslands.

The other species of grasses are Desmostachya bipinnata which is very short (not more than 40 cm) and Saccharum spontaneum which occupies a small area but grows upto 4 m in height. Tree and shrub species found in this habitat are Prosopis cineraria, Acacia nilotica, A. leucophloea, Zizyphus mauritiana, Mytragyna parviflora , Sizygium cumini and saline zone associations like Prosopis juliflora, Salvadora persica and S. oleoides (Perennou and Ramesh 1987).

2.5.4 Mixed forests

This is the smallest amongst the four habitats and includes representatives of the other three habitats. The blocks forming

the mixed forests are A,B,C,D, and part of N (Fig. 2). Grass cover is not continuous and the grass species are Desmostachya bipinnata and Cynodon dactylon. A large part of this habitat has saline zone associations : Prosopis juliflora, Salvadora persica, S. oleoides forming dense undergrowth in some areas. Acacia nilotica is also abundant in the mixed forests. The largest patch of Mytragyna parviflora (dense and scattered) is found here. Other tree and shrub species include Ziziphus mauritiana, Prosopis cineraria, and Syzygium cumini .
Small portions of the wetland (Sitaram 'Diggi') are found within the mixed forests.(Fig. 1).

2.6 **DISTURBANCE**

Villages, including agricultural fields which surround the Park, and cattle and buffaloes that were previously let into the Park, are a constant source of disturbance to the Park.

Cutting of grass, to avoid people letting in their cattle, caused a new kind of disturbance. Illegal cutting of grass takes place after July as permits are not issued once the migratory birds arrive and cutting should not take place in the glowing season.

Paths inside the Park are frequently used by villagers and fires are common in the grasslands. (Fig. 3).

The three temples located inside the Park are a constant source of attraction to worshippers and therefore a source of disturbance to the Park. (Fig. 3).

FIG 1 BLOCK DIVISION OF KEOLADEO NATIONAL PARK, BHARATPUR.

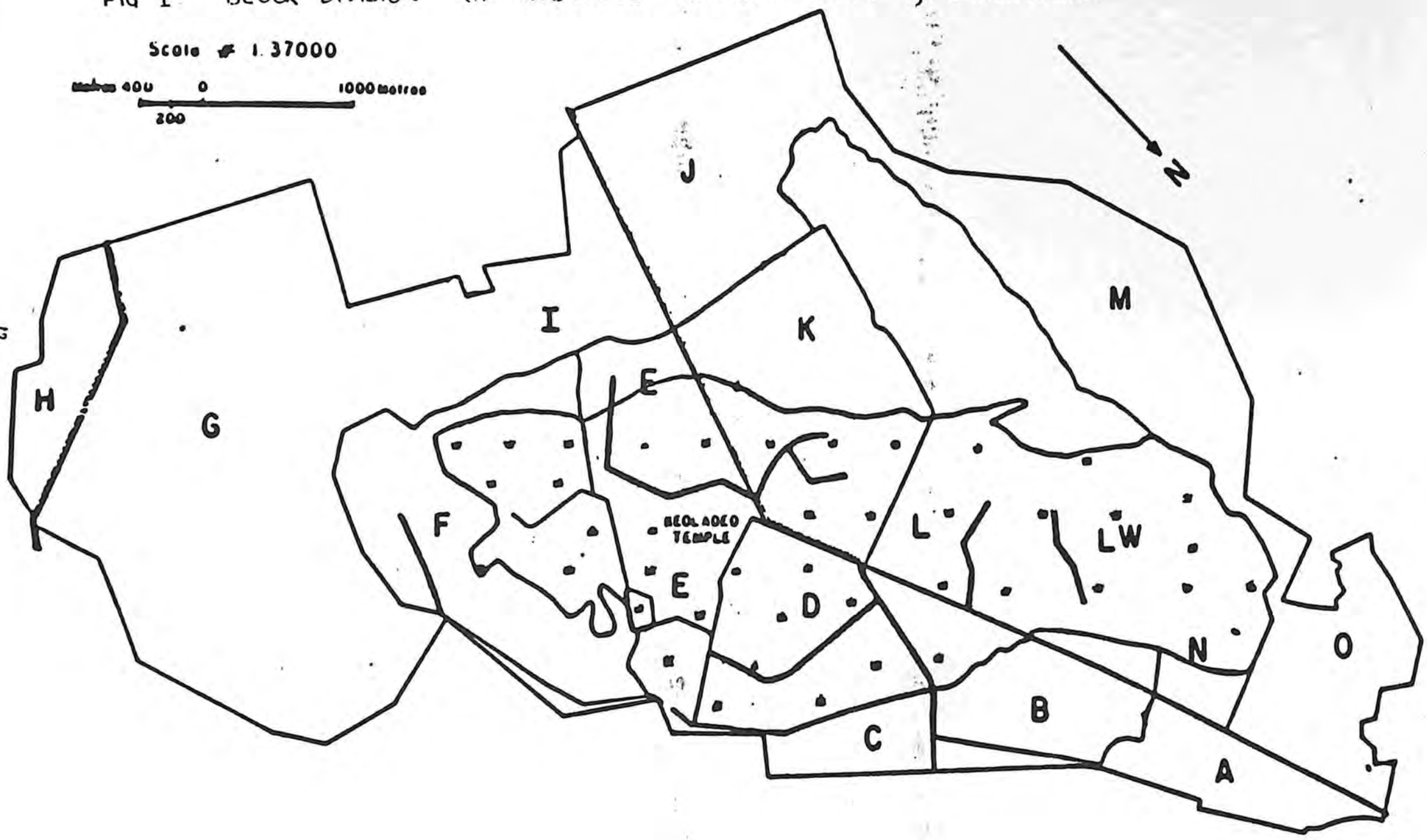


FIG. 2. THE FOUR MAJOR HABITAT TYPES IN KEOLADEO NATIONAL PARK, BHARATPUR.

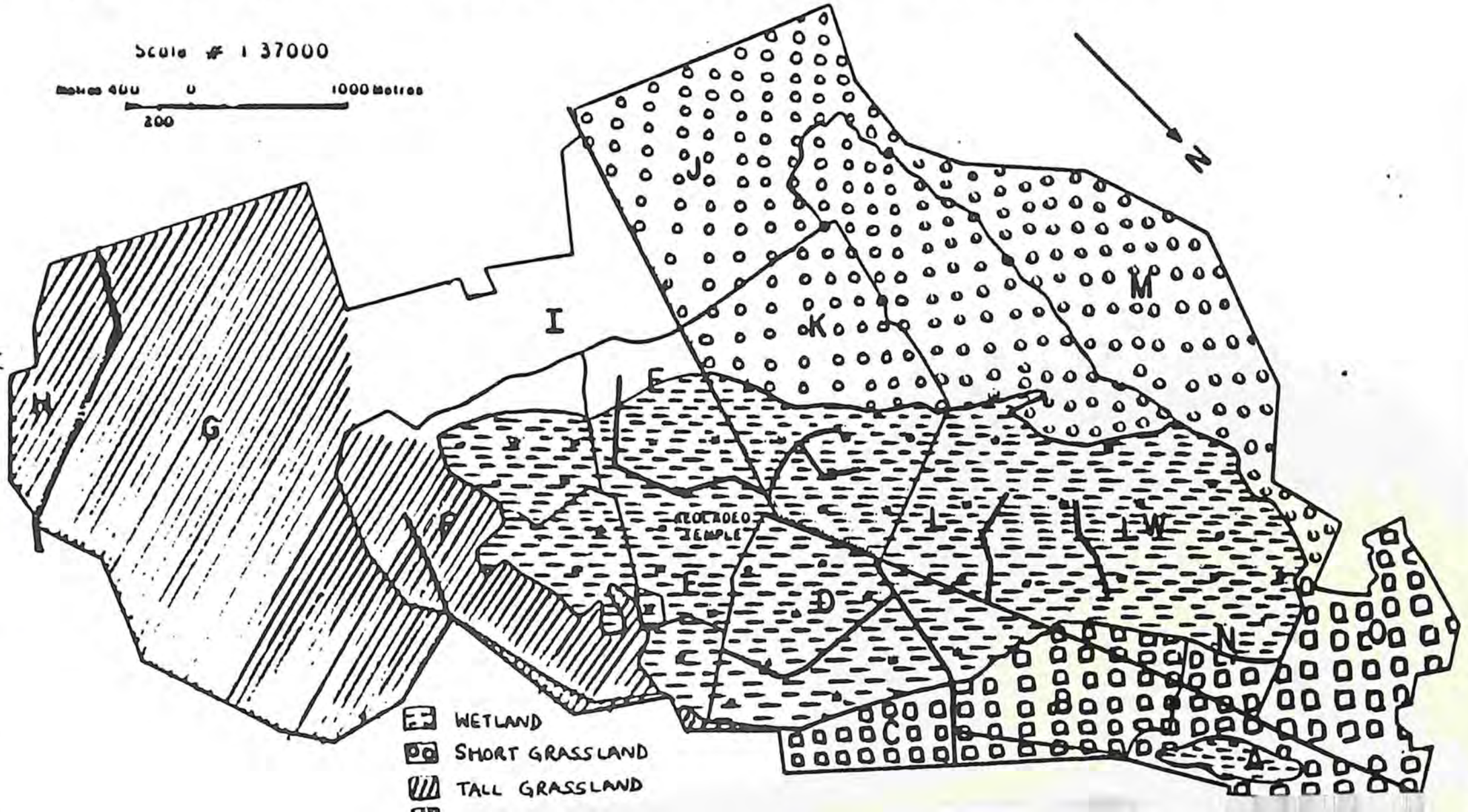
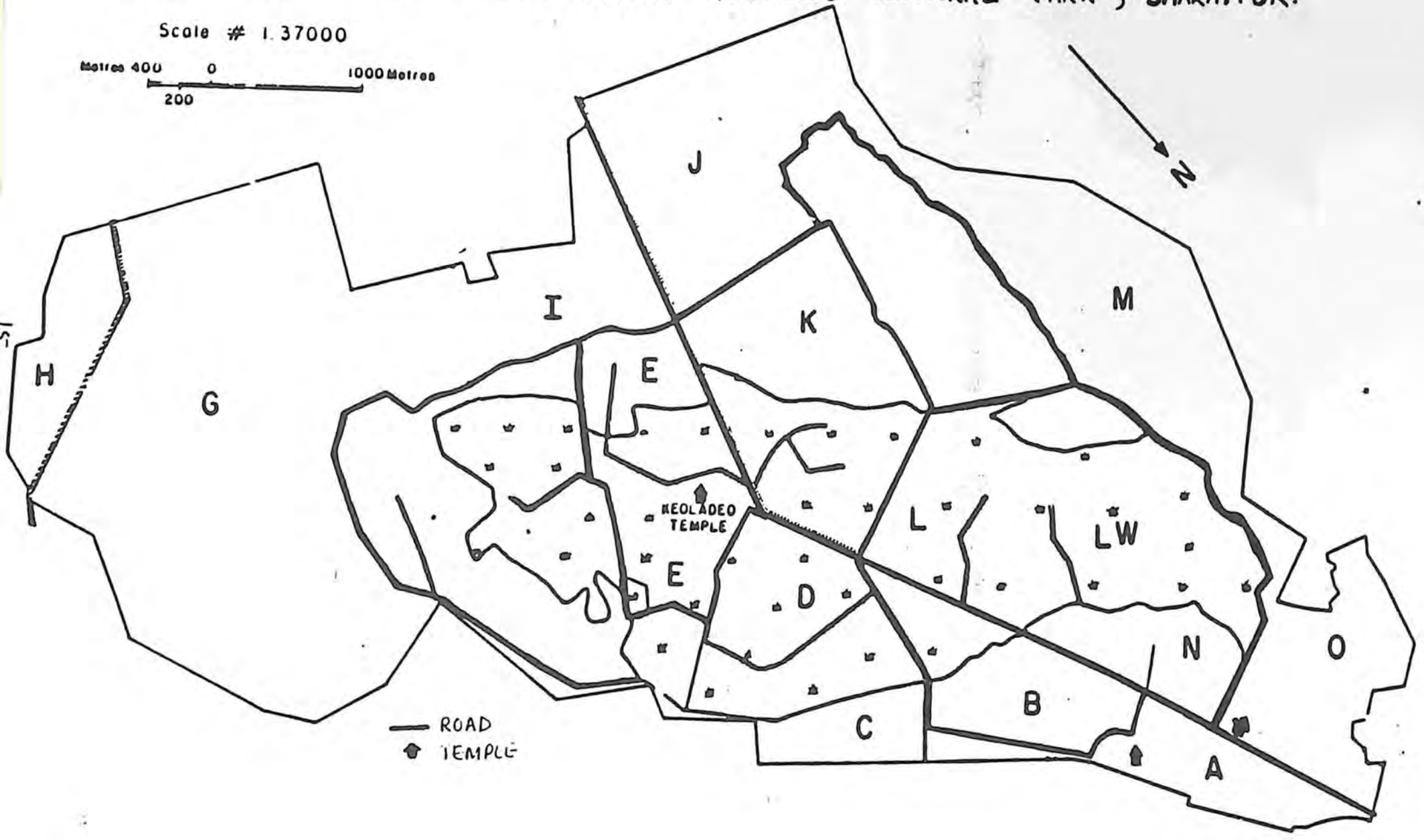


FIG. 3 ROADS AND TEMPLES WITHIN KEOLADEO NATIONAL PARK, BHARATPUR.



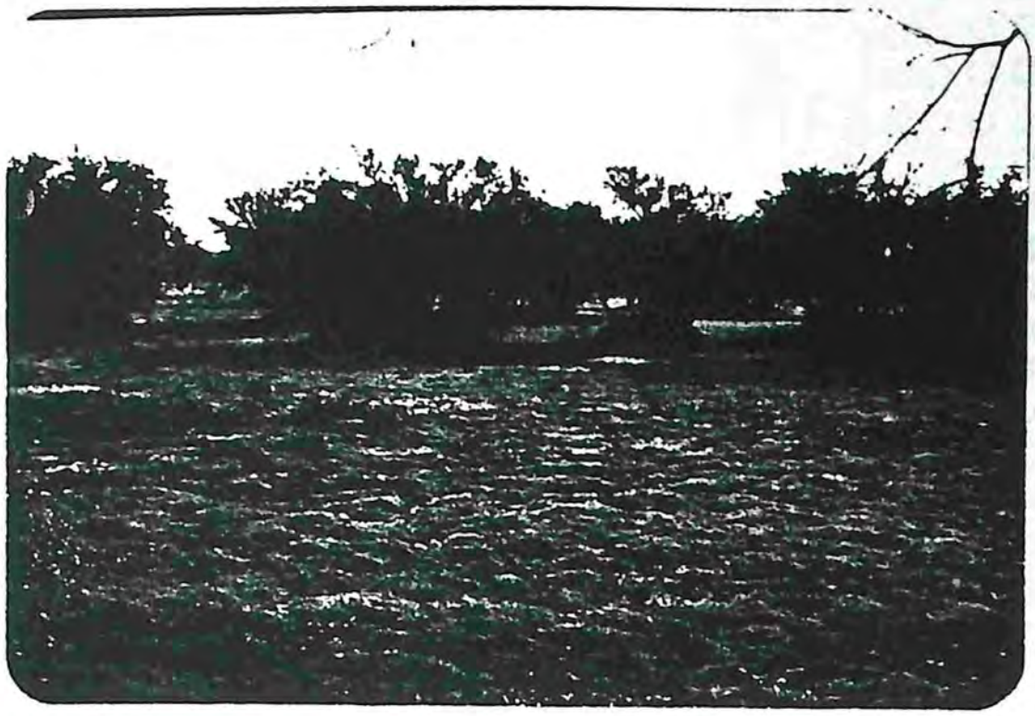


Plate 1a. Wetland in summer.

Plate 1b. Wetland in monsoon.

CHAPTER - III

METHODS

3.1 FIELD METHODS

Most of the lesser carnivores are nocturnal, shy and hence difficult to observe. The best way to study them would be to trap, ear-tag and radio-collar many individuals of a species and follow them. Other studies on leser carnivores involved tagging (Robinson and Grand 1958) or radio collaring (Major and Sheburne 1987), or were relatively inefficient in data collection (Geertsema 1985).

Radio telemetry was ruled out for this study for the following reasons :

(1) This was a short term study.

(2) Transmitters for small carnivores were not available.

(3) We had no experience of capturing such animals.

As no past ecological or behavioural studies have been made on free ranging predators in India the methods followed in this study are hence experimental and modifications of those used elsewhere (e.g., Waser 1980). I attempted several methods for locating the carnivores, determining their food habits, habitat use and time of activity. Methods found unsuitable were discontinued.

Five methods are discussed in detail below :

The four habitat types described in the section on study area totalled c.26.5 km^2 (Table-1). A section of the park approximately 2.5 sq.km. was not covered during this study due to inaccessibility during the monsoons.(Fig. 1).

3.1.1 LINE TRANSECTS

These were to estimate prey abundance and obtain carnivore sightings. Length of transects were in rough proportion to the area of the habitat (Table-1).

In the tall grasslands straight firelines and in short grasslands trails were chosen as transects. These transects traversed through different communities in the grassland. Wetlands were flooded during the monsoons so roads were chosen as transects in this habitat. (Fig. 4).

I started walking the morning transects at 0530 hrs. and the night transects at 1945 hrs. Approximately an hour was spent on each 2 km transect and half an hour over a 1 km transect.

The total time spent and distance covered along transects in each habitat during the summer and winter time periods are summarised in Table-2 :

I walked the night transects with a rechargable flashlight (Sanyo). The flashlight was completely charged at the start of every transect.

Prey species such as amphibians, reptiles, groundbirds, rodents and lagomorphs within the range of the flashlight were recorded. Information such as time of observation, number of individuals and sighting distance were recorded. For the carnivores I also included the activity at the time of observation.

Transects were found unsuitable to locate rare carnivores especially the otter and the fishing cat. No otter sightings and only two fishing cat sightings were obtained. Therefore night

line transects were given up from July onwards but continued in the mornings for prey estimation.

3.1.2 SEARCHES

This method was used primarily to increase sightings of carnivores. The starting time of these searches was 0530 hrs and 1945 hrs. The length of each search was proportional to the area of the habitat. The length of the various search route was 1 km in mixed forests and 2 kms in the other habitats.

The searches did not follow any particular pattern and were not permanent. They were done in different areas of the main habitats. Alarm calls of potential prey species (example Red wattled lapwing Vanellus indicus) were used for locating the carnivores as were vocalisations of carnivores.

Data on carnivores and prey species on morning and night searches were collected as explained in the line transects.

Time spent and distance covered on searches for different seasons in each habitat is given in the Table-3 :

3.1.3 SCAT COLLECTION

The only meaningful and non-destructive way of collecting data on the food habits of lesser carnivores is to systematically collect sufficient number of their scats and identity the remains found (therein)

Scats were collected to

(1) Determine the diet of the three sympatric carnivores.

(2) To show whether and how the three carnivores differ in their diet.

Scats of all three species were collected whenever encountered. Fishing cat scats were differentiated from jungle cat scats by their size. Scats larger than 2 cm diameter were regarded as fishing cat scats while those with a diameter smaller than 2 cms were assumed to be jungle cat scats as fishing cats (130 cms.: 11-15 kgs.) are much larger than jungle cats (90-100 cms : 5-9 kgs.). Scats which were difficult to identify were put under the unknown category. Data from these scats are not presented here.

Scats were collected in plastic bags and tagged with notes on the species freshness, date and place of collection.

3.1.4 BEHAVIOURAL OBSERVATIONS

Casual encounters with carnivores on numerous occasions gave an opportunity to make behavioural observations by focal animal observation (Altman 1974). Two rechargable flashlights were used for night observations. When an animal was sighted I stayed with it for as long as possible. I could approach the fishing cat up to a minimum distance of 20 mts., the jungle cat upto a minimum distance of 2 mts. and jackals upto 10 mts.

3.1.5 ESTIMATION OF JACKAL NUMBER - HOWL COUNTS

Use of vocalisation to establish the number of territorial species has been well documented in several cases (Joslin 1967, Pimlott et al 1969, Voigt 1973). Data was collected along transects and searches whenever howls were heard. The time, number of packs howling and the habitat in which the howls were heard was recorded.

Combined with average group size data from encounters this method has given an approximate estimate for the jackal populations in Keoladeo National Park.

Table-4 shows average number of packs howling in each area for the four habitats and their population in the entire park during the study period.

3.2 ANALYTICAL METHODS

3.2.1 PREY ABUNDANCE

Transect and search data on prey species were combined. Separate tables (5 & 6) were made for the morning and night data. Seasonal variations in prey species abundance were estimated as encounter rates per hour for each habitat.

For each season, total number of hours spent, max. sighting distance for different prey species and distance walked on morning and night transects were calculated.

Encounter rates per hour for prey species were estimated by dividing averages by total distance walked.

3.2.2 HABITAT OCCUPANCE

Casual encounters were combined with encounters on searches to determine habitat occupance of the three species of carnivores.

Encounter rates per hour for each carnivore species in different habitats were calculated. This was done by dividing total number of sightings in each habitat by number of hours spent in the habitat.

Average encounter rates for each species were also calculated by dividing total encounter rates per hour by four -

the number of habitats (Table-7).

3.2.3 TIME OF ACTIVITY

Seven time classes from 0530 hrs to 0230 hrs. were used. Encounters with each carnivore species throughout the study were grouped in their respective time classes (Table 8).

Encounter rates per hour for each species was calculated by dividing the number of sightings in each time class by the total number of hours spent in that time class over the entire study period.

3.2.4 SCAT ANALYSIS

All collected scats were immediately oven dried to protect them from insect attack. Later they were soaked in water and washed in a 0.5 mm sieve to free them from soil. After washing samples collected for study were oven dried again.

Remains from the scats such as bones, vegetable material (seeds and grass), insect remains, fish scales, feathers and mammalian hair were separated in each scat.

Tables 9 (a,b,c,d), 10 and 11 show visual percentage estimates for each prey item for the three species of carnivores in different habitats. Percentages below five for any item were considered as "trace" and not included in the summed totals.

With the data from tables 9,10 and 11 dietery overlap between jungle cat - fishing cat ; jungle cat - jackal and fishing cat - jackal was calculated (Table-12) in the following way :

The percentages of each prey item were converted to proportions. Schoener's niche overlap index (1970) was used to measure overlap from the final proportions of the prey items.

$$Cxy = 1 - 0.5 \left(\sum_i |Pxi - Pyi| \right)$$

Pxi = Proportion of species x using resource i.

Pyi = Proportion of species y using resource i.

The overlap values range from 0 to 1. A value of zero would mean no overlap and a value of one would indicate complete overlap with respect to the resource utilised.

Using data from Tables 9 a and b ,I tested the following hypothesis related to jungle cat.

1 Prey species eaten in the Wetlands and Short grasslands differed.

2 Proportions of mammals and birds eaten in the above two habitats varied.

Spearman Rank correlation test was used to prove hypothesis one and Mann Whitney U-test (Siegel 1956) was used to prove hypothesis two. (equations in Appendix).

FIG. 4. LINE TRANSECTS IN THE FOUR MAJOR HABITATS OF KEOLADEO NATIONAL PARK, BHARATPUR.

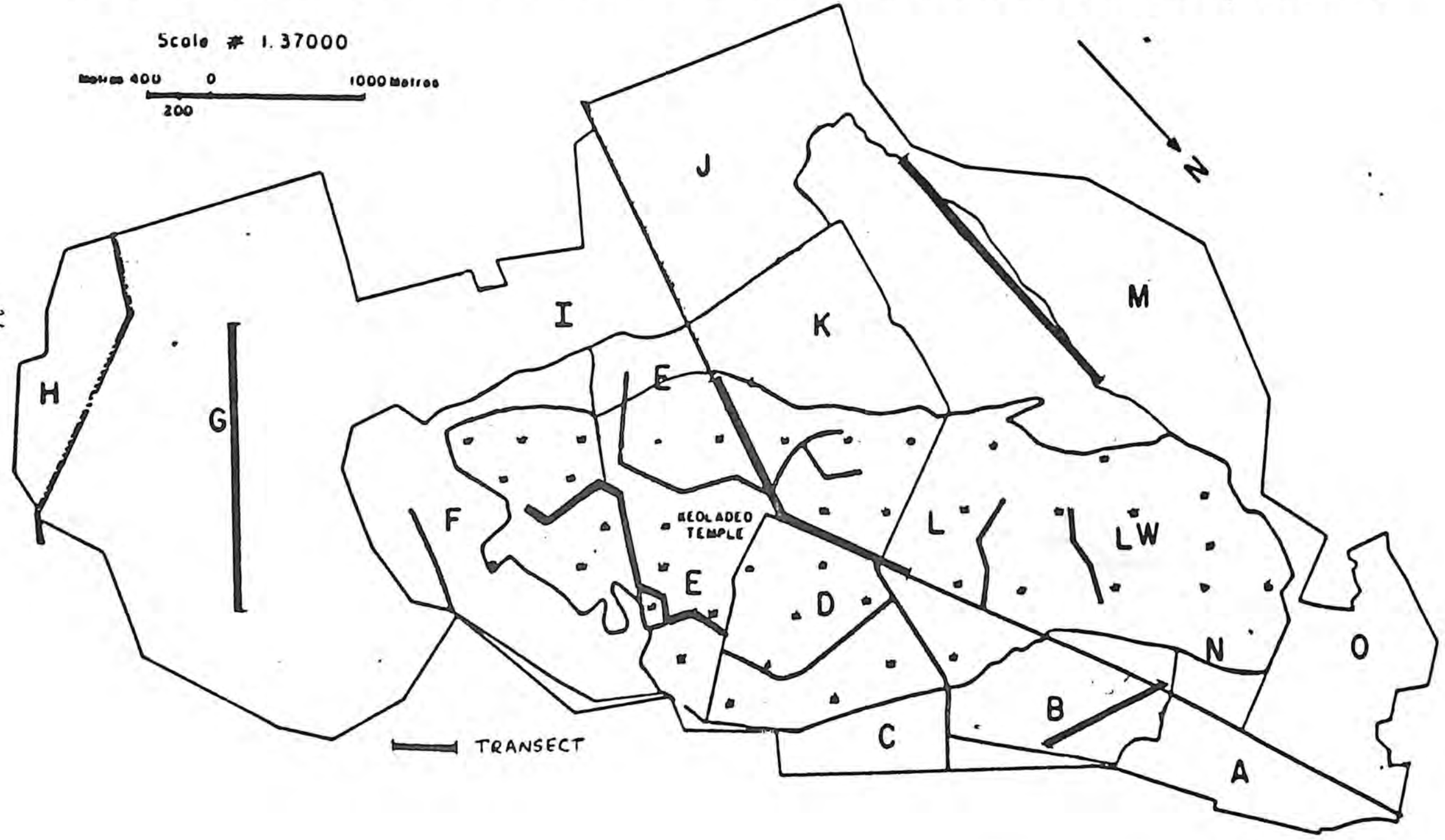


Table-1 : Area and length of transects in different vegetation types.

HABITAT	AREA	TRANSECT LENGTH	NO. OF TRANSECTS
Wetland	10.5 sq.km.	2 km	2
Short grassland	6.0 sq.km.	2 km	1
Tall grassland	6.5 sq.km.	2 km	1
Mixed Forest	3.5 sq.km.	1 km	1

Table-2 : Time spent and distance covered in different habitat types by line transect in summer and monsoon.

HABITAT	MORNING				NIGHT	
	SUMMER		MONSOON		TIME	DIST.
	TIME	DIST.	TIME	DIST.		
Wetlands	4 hrs.	8 kms.	4 hrs.	8 kms.	4 hrs.	8 kms.
Short-grasslands	2 hrs.	4 kms.	2 hrs.	4 kms.	2 hrs.	4 kms.
Tall-grasslands	2 hrs.	4 kms.	-	-	2 hrs.	4 kms.
Mixed Forest	1 hr.	2 kms.	1 hr.	2 kms.	1 hr.	2 kms.

Table-3 :Time spent and distance covered in different habitat types in different times by searches in summer and monsoon.

A - SUMMER

HABITAT	MORNING		NIGHT	
	TIME	DIST.	TIME	DIST.
Wetlands	4 hrs.	8 kms.	6 hrs.	12 kms.
Short grasslands	2 hrs.	4 kms.	3 hrs.	6 kms.
Tall grasslands	2 hrs.	4 kms.	3 hrs.	6 kms.
Mixed forest	1 hr.	2 kms.	1.5 hrs.	3 kms.

B - MONSOON

HABITAT	MORNING		NIGHT	
	TIME	DIST.	TIME	DIST.
Wetlands	4 hrs.	8 kms.	20 hrs.	40 kms.
Short grasslands	2 hrs.	4 kms.	10 hrs.	20 kms.
Tall grasslands	-	-	1 hrs.	2 kms.
Mixed forest	1 hr.	2 kms.	5 hrs.	10 kms.

TABLE 4

ESTIMATION OF JACKAL POPULATIONS IN KEOLADEO NATIONAL PARK (MAY – OCTOBER, 1989).

HABITAT	BLOCKS	NO. OF PACKS HEARD HOWLING RANGE	$\bar{x}$ PACKS HEARD	MEAN LITTER SIZE	Av. No. OF JACKALS (av no of packs x 3 litter size x 2 adults)	TOTAL	RANGE
WETLAND	L	2-3	2·30	3·18	14·62	42·6	12·72 – 19·08
WETLAND	E & D	1-3	2·00	3·18	12·72		6·36 - 19·08
WETLAND	LW	2-3	2·40	3·18	15·26		12·72 – 19·08
SHORT GRASSLAND.	J, K, M.	1-3	1·80	3·18	11·44	11·44	6·36 - 19·08
MIXED FOREST	A & M	1-2	1·25	3·18	7·95	23·85	6·36 – 12·72
MIXED FOREST	B & N	1-2	1·00	3·18	6·36		6·36 - 12·72
MIXED FOREST	C	1-2	1·50	3·18	9·54		6·36 - 12·72
TOTAL POPULATION RANGE 76·24 – 133·56 IN 29 KM^2							

NOTE: IN THE TALL GRASSLANDS NO PACKS WERE HEARD HOWLING BUT ATLEAST THREE PARKS ARE PRESENT. THEREFORE, AVERAGE NUMBER OF JACKALS IN TALL GRASSLANDS ARE 19·08.

TABLE 5.

PREY ABUNDANCE IN THE VARIOUS HABITATS OF KEOLADEO NATIONAL PARK ON MORNING SEARCHES.

HABITAT	TOTAL TIME SPENT	DISTANCE WALKED	NO. OF TRAN-SECTS /SEARCH	MAMMALS		AVES	
				Er/km*	D.**	Er/km	D.
WETLANDS SUMMER	8 HR	16 KM	8	1·03	20	16·50	20
MONSOON	8 HR	16 KM	8	1·12	20	10·80	10
SHORT GRASSLAND SUMMER	4 HR	8 KM	4	0·62	10	11·12	20
MONSOON	4 HR	8 KM	4	1·75	10	8·12	15
TALL GRASSLAND SUMMER	4 HR	8 KM	4	0	-	9·50	10
MONSOON	0	0	0	0	-	0	-
MIXED FOREST SUMMER	2 HR	4 KM	4	1·25	10	15	20
MONSOON	2 HR	4 KM	4	1·75	10	7·56	10

* ENCOUNTER RATE PER KILOMETRE.

** MAXIMUM SIGHTING DISTANCE IN METRES.

TABLE 6.

PREY ABUNDANCE IN THE VARIOUS HABITATS OF KEOLADEO NATIONAL PARK ON NIGHT SEARCHES.

HABITAT	TOTAL TIME SPENT	DISTANCE WALKED	NO. OF TRANSECTS/ SEARCHES	MAMMALS		AVES		REPTILES		AMPHIBIANS	
				Er/KM*	D**	Er/KM	D.	Er/KM	D	Er/KM	D
WETLANDS SUMMER	10 Hr	20 Km	10	2·35	10	3·0	10	0·25	10	3·30	< 5
MONSOON	20 Hr	40 Km	20	2·85	10	0·20	5	0·45	10	1·40	< 5
SHORT GRASSLAND SUMMER	5 Hr	10 Km	5	2·20	10	0·90	10	0	–	0	–
MONSOON	10 Hr	20 Km	10	3·35	5	0·40	5	0	–	0	–
TALL GRASSLAND SUMMER	5 Hr	10 Km	5	0·20	15	1·60	15	0	–	0·40	< 5
MONSOON	1 Hr	2 Km	1	1·50	5	0·50	10	0·50	5	0·50	< 5
MIXED FOREST SUMMER	2·5 Hr	5 Km	5	1·60	5	0	15	0	–	0·20	< 5
MONSOON	5 Hr	10 Km	10	1·50	10	0·05	10	0	–	0·10	< 5

* ENCOUNTER RATE PER KILOMETRE.

** MAXIMUM SIGHTING DISTANCE IN METRES.

TABLE 7.

SIGHTINGS OF THREE CARNIVORES IN DIFFERENT HABITATS IN KEOLADEO NATIONAL PARK

SPECIES	N*	AVERAGE Er	HABITAT: WETLAND		TALL GRASSLAND		SHORT GRASSLAND		MIXED FOREST	
			n	Er**	n	Er	n	Er	n	Er
JUNGLE CAT	28	0.0265	21	0.028	1	0.05	3	0.02	3	0.008
FISHING CAT	34	0.0115	34	0.046	0	0	0	0	0	0
JACKAL	127	0.105	77	0.105	3	0.15	6	0.05	41	0.118
TOTAL			132		4		9		44	
APPROX NO. OF HRS. SPENT			730		20		110		345	

* NUMBER OF SIGHTINGS.

TABLE 8.

TIME OF ACTIVITY OF THREE CARNIVORES, KEOLADEO NATIONAL PARK.

← TIME CLASSES →

SPECIES	N_1	5:30 AM – 9:30 AM		9:31 AM – 12:30 AM		12:31 AM – 15:30 PM		15:31 PM – 18:30 PM		18:31 PM – 21:30 PM		21:30 PM – 12:30 AM		12:31 AM – 2:30 AM	
		n	Er	n	Er	n	Er	n	Er	n	Er	n	Er	n	Er
JUNGLE CAT	28	0	0	0	0	0	0	1	·017	25	·083	2	·007	0	0
JACKAL	127	23	·096	2	·022	13	·104	15	0·25	66	·589	8	·027	0	0
FISHING CAT	34	0	0	0	0	0	0	0	0	21	·07	13	·043	0	0
N_2		23		2		13		16		112		23		0	
APPROX. NO. OF HOURS SPENT		240 Hrs.		90 Hrs.		125 Hrs.		60 Hrs.		300 Hrs.		300 Hrs.		90 Hrs.	

N_1 = TOTAL SIGHTINGS FOR EACH SPECIES.

N_2 = TOTAL SIGHTINGS OF THREE SPECIES IN EACH TIME CLASS.

TABLE 9(a).

JUNGLE CAT SCAT ANALYSIS — TALL GRASSLANDS.

[n = 3]

PREY ITEMS / DATE	HAIR	BONES	FEATHERS	FISH	INSECTS	VEGETABLE MATERIAL	OTHERS
MAY 21st	95%	0	0	0	0	5%	0
MAY 28th.	100%	TRACE	0	0	0	TRACE	0
JUNE 23rd	45%	5%	45%	5%	0	TRACE	0
AVERAGE	80%	1·66%	15·0%	1·66%	0	1·66%	9

TABLE 9(b).

JUNGLE CAT SCAT ANALYSIS – WETLANDS [n = 11]

DATE / PLACE ↓ / PREY ITEMS →		HAIR	BONES	FEATHERS	FISH	INSECTS	VEGETABLE MATERIAL	OTHERS
MAY 20th	SAPAN MORI	45%	10%	45%	0	0	0	0
MAY 22nd	SAPAN MORI	45%	10%	45%	0	0	0	0
MAY 23rd	SAPAN MORI	40%	0	60%	0	0	0	0
MAY 15th	BAKALYA	90%	5%	TRACE	0	0	5%	0
MAY 27th	BAKALYA	95%	5%	0	0	0	0	0
MAY 30th	BAKALYA	90%	5%	TRACE	0	0	5%	TRACE
JUNE 22nd	BEHIND SHORT GRASS	50%	40%	5%	0	TRACE	5%	0
JUNE 24th(A)	KADAM KUNJ	0	5%	95%	0	0	0	TRACE
JUNE 24th(B)	KADAM KUNJ	10%	50%	20%	20%	0	0	0
JUNE 24th(C)	KADAM KUNJ	0	0	100%	0	0	0	0
JUNE 24th(D)	KADAM KUNJ	0	5%	95%	TRACE	0	0	0
AVERAGE		42.27%	12%	42.27%	2.0%	0	1.4%	0

TABLE 9 (c).

JUNGLE CAT SCAT ANALYSIS – SHORTGRASSLANDS.

[n=7]

DATE	PREY ITEMS / PLACE	HAIR	BONES	FEATHERS	FISH	INSECTS	VEGETABLE MATERIAL	OTHERS
MAY 6th (A)	LALA PYARA	100%	TRACE	0	0	TRACE	TRACE	0
MAY 6th (B)	LALA PYARA	100%	TRACE	0	0	TRACE	TRACE	0
MAY 25th	TRAIL 3	90%	10%	TRACE	0	0	TRACE	0
MAY 25th	TRAIL 3	95%	5%	0	0	0	0	0
MAY 26th	TRAIL 3	95%	5%	0	0	0	0	0
JUNE 24th	TRAIL 3	100%	TRACE	0	0	0	TRACE	0
JUNE 24th	TRAIL 3	100%	TRACE	TRACE	0	0	TRACE	0
AVERAGE		97%	3%	0	0	0	0	0

TABLE 9(d).

JUNGLE CAT SCAT ANALYSIS - MIXED FORESTS

[n = 6]

PREY ITEMS / DATE	HAIR	BONES	FEATHERS	FISH	INSECTS	VEGETABLE MATERIAL	OTHERS
MAY 23rd	100%	TRACE	0	0	0	0	0
JUNE 1st	90%	5%	TRACE	TRACE	TRACE	0	TRACE
JUNE 14th	95%	5%	0	0	0	0	0
JUNE 14th	35%	60%	0	0	0	5%	0
JUNE 23rd	65%	5%	30%	0	0	TRACE	0
AUGUST 9th	0	100%	0	0	0	0	0
AVERAGE	63·83%	29·33%	5·08%	0·33%	0·33%	1%	0·08%

TABLE 10.

JACKAL SCAT ANALYSIS – SUMMER AND MONSOON.

[n = 14]

DATE / PLACE / PREY ITEMS		HAIR	BONES	FEATHERS	FISH	INSECTS	VEGETABLE MATERIAL		OTHERS
							SEEDS	GRASS	
MAY 16th	WETLANDS	TRACE	TRACE	TRACE	TRACE	TRACE	10	90	0
MAY 16th		5	5	0	0	0	0	90	0
MAY 23rd		70	0	0	10	10	0	10	0
JUNE 2nd		TRACE	0	0	TRACE	0	10	90	0
JUNE 22nd		10	10	0	0	0	0	5	75
MAY 7th	MIXED	0	0	0	0	0	90	10	0
MAY 20th		0	0	0	0	0	0	100	0
MAY 28th		40	0	0	0	0	0	60	0
MAY 28th		50	20	0	0	0	0	30	0
MAY 28th		50	TRACE	0	0	TRACE	20	30	0
JUNE 1st		TRACE	TRACE	0	0	TRACE	0	100	0
MAY 28th	TALL GRASS	80	TRACE	TRACE	TRACE	0	20	0	0
MAY 29th		0	5	0	0	0	0	95	0
JUNE 23rd	SHORTGRASS	75	0	0	0	0	25	0	0
AVERAGE		27	2·8	0	0·71	0·71	12·5	50·7	5·3

TABLE 11.

FISHING CAT SCAT ANALYSIS.

[n = 9]

NO.	DATE	PREY ITEMS → / PLACE	HAIR	BONES	FEATHERS	FISH	INSECTS	VEGETABLE MATERIAL	OTHERS
1.	MAY 18th	KADAMKUNI	5%	10%	85%	TRACE	0	TRACE	0
2.	MAY 18th	KADAMKUNI	5%	20%	5%	15%	0	50%	5%
3.	MAY 18th	KADAMKUNI	10%	25%	TRACE	25%	5%	30%	TRACE
4.	MAY 18th	KADAMKUNI	10%	60%	0	20%	0	10%	TRACE
5.	MAY 18th	KADAMKUNI	TRACE	45%	0	50%	0	0	0
6.	MAY 20th	BISON MORI	10%	45%	0	45%	TRACE	TRACE	0
7.	JUNE 7th (A)	KADAMKUNI	10%	10%	35%	45%	TRACE	TRACE	0
8.	JUNE 7th (B)	KADAMKUNI	10%	40%	50%	0	0	0	0
9.	OCT 1st	AGHAPUR RD.	35%	5%	0	30%	TRACE	30%	0
AVERAGE			10·55%	28·88%	19·4%	25·55%	0·55%	13·33%	0

TABLE 12.

DIETARY OVERLAP FROM SCAT ANALYSIS

PREY ITEM / SPECIES	HAIR	FEATHERS	FISH	INSECTS	VEGETABLE MATERIAL		INDEX FOR NICHE OVERLAP
					SEED	GRASS	
FISHING CAT	0·15	0·27	0·37	0	0	0·18	0·41
JUNGLE CAT	0·73	0·22	0	0	0	0	
JUNGLE CAT	0·73	0·22	0	0	0	0	0·33
JACKAL	0·28	0	0	0	0·13	0·54	
JACKAL	0·28	0	0	0	0·13	0·54	0·37
FISHING CAT	0·15	0·27	0·37	0	0	0·18	

CHAPTER - IV

RESULTS

4.1 INTRODUCTION

This chapter presents the results obtained during the study, following methods described in Chapter 3.

An outline of the level of information collected during the entire study period is followed by more detailed analysis of prey abundance, habitat occupance, time of activity, scat analysis and estimation of jackal pack numbers in the different habitats.

4.2 INFORMATION COLLECTED : LIMITATIONS OF THE STUDY

Although otters were included in the study initially, they were excluded, the reasons being :

1. Very low encounter rates.
2. No otter spraints were found during the entire study period hence dietery trends for otters could not be determined as was done for the other three species.

Jungle cat, jackal and fishing cat scats were found only during the summer months, so seasonal differences in diet could not be determined.

Table 7 shows that sightings for both cat species during searches as well as casual encounters for all 6 months were very low. For jungle cat the total number of sightings on searches was the same as the number of casual encounters (14). However a difference was seen between search and casual encounters for the fishing cat (2 and 32) and jackal (26 and 98). Only two encounters were recorded on searches for the fishing cat, but the

relatively high number of casual encounters (32) was due to a single animal being repeatedly observed during the month of August.

4.3 PREY ABUNDANCE

Differences in prey abundance, expressed as an encounter rate per kilometre searched, between habitats, seasons and time of day are seen in the results (Tables 5,6).

4.3.1 NIGHT SEARCHES

Mammals (rodents and hares combined) : During night searches in summer, mammals were most abundant in the wetlands $\frac{(2.35)}{km}$, followed by the short grassland (2.20), mixed forest (1.60) and finally the tall grassland (0.2). Mammal encounters during the monsoon increased in all habitats except in mixed forests which remained the same (1.50). The highest encounter rate was seen in short grassland (3.35). The tall grassland and mixed forests had similar abundances for mammals (1.50). However this was based on a single search in the tall grassland.

Maximum sighting distance for mammals was reduced during the monsoon in the short and tall grasslands from 10 m and 15 m respectively in summer to 5 mts in the monsoons, due to increase in ground cover and grass height. Maximum sighting distance however increased in the mixed forest from 5 mts in summer to 10 mts in the monsoon as larger mammals such as porcupine were encountered more often here during the monsoon.

The mammalian species encountered during night searches were hare, porcupine and several small species of rodents (gerbils, mice).

Aves: in summer ground bird species were encountered more frequently in the wetlands (3.00) and least in the mixed forests (nil). Lack of bird sightings in the mixed forests could be due to comparatively less time spent and distance covered in the habitat. Birds were more abundant in tall grasslands (1.6) than in the short grassland (0.9).

A drop in bird encounter rate took place in the monsoon in all habitats except in the mixed forests where it increased from 0 to 0.5. This was the lowest recorded for the four habitats.

Maximum sighting distance decreased from summer to monsoons in all habitats.

Reptiles : Reptiles were encountered only in the wetlands during summer (0.25) and in the wetlands (0.45) and tall grasslands (0.5) in the monsoon. Reptiles encountered were turtles and water snakes in the wetland and water snakes in the tall grassland.

Amphibians : The high summer encounter rate for amphibians (3.3) is influenced by observing more than 50 small frogs within a radius of 5 mts on one search. Amphibians were also recorded in the tall grassland in summer (04.) and in the mixed forest (0.2). During the monsoon amphibians were most abundant in the wetlands (1.4) followed by the tall grassland (1 search) and mixed forest (0.1).

Maximum sighting distance was less than 5 mts for all habitats.

Taking each habitat separately, during summer, in the wetlands amphibians are most abundant (3.3), followed by birds (3.0), mammals (2-35) and reptiles (0.25). During the monsoon, mammalian species are most abundant.

In the short grasslands mammals are most abundant during both seasons.

Avian species are most abundant in the tall grasslands in summer whereas mammals have the highest encounter rates during the monsoon.

In the mixed forests highest encounter rates are for mammals during both seasons.

4.3.2 MORNING SEARCHES

On morning searches only mammals and birds were encountered (Table 5). Mammalian species seen during the day were different from those encountered at night. Squirrels were the most common mammalian species seen during the day. Hare were also encountered on some occasions.

Mammals : In summer, mammals were most abundant in the mixed forest (1.25), followed by wetlands (1.03) and shortgrassland (0.62). No mammals were seen in the tall grassland.

During the monsoon shortgrasslands and mixed forest had the highest abundances for mammals (1.75) while there were no sightings of mammals in the tall grasslands.

Maximum sighting distance in the wetlands during summer and monsoon was 20 m and in the shortgrasslands and mixed forests was 10 m.

Birds : Birds species abundances by morning searches are high

compared to night searches. The highest in summer was in the wetlands (16.50). mixed forests (15.00), short grassland (11.12) and tall grassland (9.50) followed.

During the monsoon, there was a drop in bird encounters in all 4 habitats. Maximum rates for birds were in the wetlands (10.8), short grasslands (8-12) and mixed forests (7.56) followed.

Maximum sighting distance decreased during the monsoon from 20 m to 10 m. in the wetlands and mixed forests, 20 m to 15 m in the short grasslands and was 10 m in the tall grassland during summer.

Looking at each habitat separately, birds were most abundant in all habitats in summer and monsoon. Encounter rates for birds on morning searches were higher than for night searches during both seasons. Mammals were much less abundant during the daytime in all habitats in summer and in all except one (mixed forest) during the monsoon.

Due to inaccessibility in the wet months tall grasslands could not be searched.

4.4 HABITAT OCCUPANCE

Amongst the three species of carnivores, encounter rates per hour, which are an index of relative abundance were the highest for jackals in all habitats.

Jungle cats were found in all habitats but at low encounter rates (averge 0.026).

Fishing cats were restricted to the wetlands and had an encounter rate (.046) higher than jungle cats in that habitat.

Maximum encounter rates for jungle cat were in tall grasslands (0.05) but this was based on one sighting in 20 hours. This was higher than encounter rates in wetlands (0.028) with a total of 730 hrs of search. Encounter rates in the shortgrassland (0.02) were higher than in mixed forests (0.008).

Jackals were most often encountered in tall grassland (0.15) followed by mixed forests (0.118), wetlands (0.105) and least encountered in the short grassland (0.05).

4.5 TIME OF ACTIVITY (TABLE 8, Fig. 5)

Jackals were most active throughout the day, reaching a small peak from 0530 - 0930 hrs. and a large peak at 1830 hrs to 2130 hrs.

Jungle cats were active from 15-31 hrs to 1230 hrs., activity reaching a peak between 1831-2130 hrs. (0.083). 1830 hrs to 1230 hrs was the activity period of the fishing cat reaching a peak at 1830-2130 hrs (0.43).

Within each time class :

1. Amongst the three carnivores only jackals were sighted from 0530 hrs - 1530 hrs.
2. From 1831 to 2130 hrs. jackals were encountered more (0.589) often than jungle cats (0.083) and fishing cats (0.07).
3. Most of the encounters from 2131 hrs to 1230 hrs were of fishing cats (.043) followed by jackals (0.027) and jungle cats (0.007).

4.6 SCAT ANALYSIS

Despite intensive searches especially of areas known to have

cats, a total of only 50 identifiable scats were found in the whole study: 9 of fishing cat, 27 of jungle cat and 14 of jackal. Details of season and location of collection are given in table.

Table 12 shows the five prey items and their proportion found in the scats of each species. Looking at each prey item seprately insect remains were present at trace levels (< .05) in all species. Fish scales were found in traces in jungle cat and jackal scats, vegetable matter in jungle cat scats and feathers in jackal scats.

Proportion of fish scales was highest in fishing cat scats (average 0.37) present in 8 out of 9 samples. Mammal hair dominated jungle cat scats (0.73) and vegetable matter comprised over half the faecal material in jackal scats (0.13 seeds and 0.54 grass).

Dietery overlap between the two species of cats was found to be the highest (0.41) using Schoener's niche overlap index (Chapter 3). Overlap between jackal and fishing cat was higher (0.37) than between jackal and jungle cat (0.33).

The Spearmans Rank Correlation test, analysing different dietary composition in different habitats for the jungle cat scats showed an r_s value of 0.657. This is not significant. For sample size seven r_s value should be 0.714 or above. However examination of table 9b,c does show a trend towards an equal proportion of hair & feathers in wetlands habitat compared to a greater proportion of ~~feathers~~ hair in the hortgrassland habitat.

The Mann Whitney - U test was used to analyse differences in the proportions of prey items (mammalian hair and feathers) obtained in jungle cat scats in the different habitats

(shortgrassland and wetland).

U showed a value of 3 for mammalian hair, significant at the .002 level and 10.5 of feathers significant at the .02 level. For number of samples in shortgrassland (n_1) equal to 7 and the number of samples in wetlands (n_2) equal to 11 and at a significance level of .002. U should have a value equal to or less than 6. For same n_1 and n_2 but at significance level .02 the value of U should be less than or equal to 12. Since the values of U for hair and feathers fall within the required value, the hypothesis is statistically proved.

4.7 **JACKAL PACK NUMBERS BY HOWL COUNTS** (Table 4).

The maximum number of packs howling were from block L.W. of the wetlands (average 2.4).

The wetlands on the whole had a larger number of packs howling (2.2) than the short grasslands (1.8) and mixed forest (1.25).

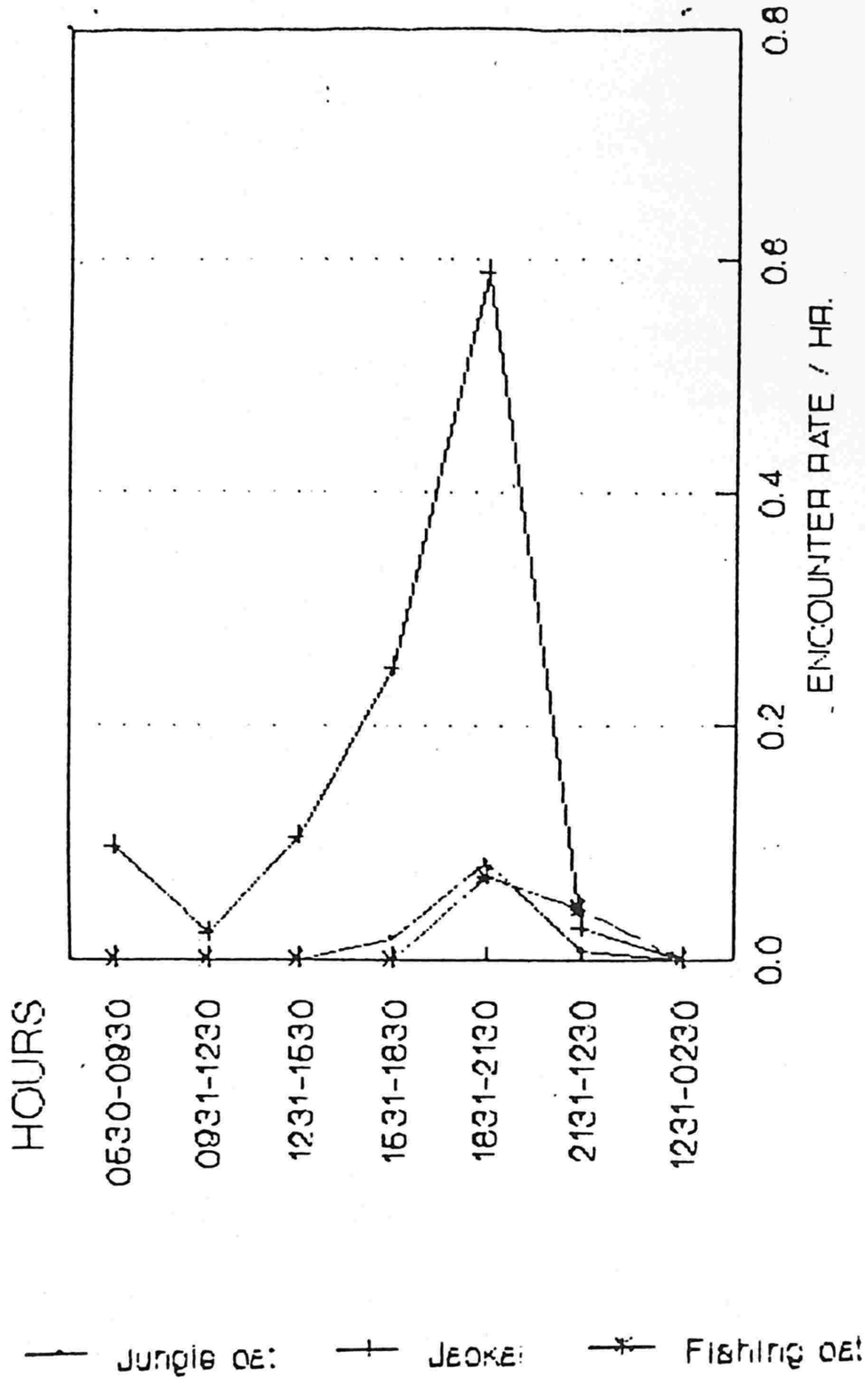


Fig .5 Time of activity of three carnivores in Keoladeo National Park.

CHAPTER - V

DISCUSSION

5.1 INTRODUCTION

5.1.1 Habitat and Niche

The concept of ecological niche is a relatively recent one. It has often been confused with the term 'habitat' (Odum 1971).

The most simple definition of habitat would be 'The place where an organism lives. However habitat can also be used (perhaps over-loosely) to describe an area occupied by an entire community. The habitat therefore, includes the biotic and abiotic environment of an organism, group of organisms or an entire community (Odum 1971).

Charles Elton (1927) made the distinction between niche and habitat by emphasising energy flows in his definition of the niche. He defined niche as "the functional status of an organism in its community" (Odum 1971).

Thus the niche takes into account several aspects or 'dimensions', habitat being just one of them. Hutchinson, in his definition of niche summed it all up as" an 'n' dimensional hyper-volume", where each dimension is an environmental gradient.

With this definition of niche came Hutchinson's distinction between the fundamental niche and the realised niche. These in short mean the niche occupied by population without any constraints by competition with others, and the niche occupied by a species or organism under biotic constraints, (Odum 1971). The realised niche would thus be smaller or more limited than the fundamental niche.

5.1.2Niche overlap and competition

Every population occupies a specific niche due to certain specific requirements for habitat type, diet, temperature and other parameters. Species which are sympatric may have similarities in their requirements for some of the parameters which would lead to an overlap. This overlap is termed as niche overlap the degree of which is potentially measurable.

Colwell and Futynma (1971) defined niche overlap as a resource or resources shared by two species. Several indices of niche overlap have been formulated. By using a resource matrix (with resource states as columns and species to be compared as rows), the use of resource states by two or more species can be compared. If the two species are identical in their use of the resource states then their niches with respect to these resourse states would overlap completely. If none of the resource states are shared then their niches with respect to these resource states would not overlap at all (Colwell, Futuyma 1971).

One of the most simple measure of niche overlap :

$Cxy = 1 - 0.5 (\leq |Px_i - Py_i|)$ used by Schoener (1970)

Where Px_i is the proportion of species x using resource i and Py_i is the proportion of species y using resource i.

The measure C takes its minimum value of 0 when species x and y share no resource states and a maximum value of 1 when all the resource states are shared proportionally by the two species (Colwell, Futuyma 1971).

Hulbert (1978) argues about the validity of this index for the measurement of overlap. According to him it is a similarity index which can give different results when compared to a more

suitable overlap index. The basis of his argument is that resource abundances and variations in abundances are ignored in this index. However, at the relatively simple level of understanding needed for this short study period. I accept Schoener's index as giving values of biological interest in examing niche occupance.

Competition can be defined as an interaction between two or more species in which at least one species is kept from using its resources efficiently (Boer, Pieter 1986). This would happen when the two species share or part share a common resource. Gause's Competitive Exclusion Principle states that due to the result of competition, two similar species would not occupy similar niches. They would instead displace each other in such a manner that each species adapts to some particular modes of life and food in which it has an advantage over its competitor.

The niche overlap index has often been used to measure competition. However, many authors dispute the use of this index as a measure for competition (Slobodchikoff and Schulz 1980 ; Colwell, Futuyma 1971 , Hurlbert 1978 , Boer 1986).

According to Slobodchikoff and Schulz (1980), ,mere overlap measures in resource cannot be taken as a measure for competition. Competition would also depend on resource abundance and population of competing species.

Hurlbert (1978) concludes that if resources are not scarce or limiting then two similar species would tolerate even complete overlap with respect to that particular resource. In this case even complete overlap would not guarantee competition. He also

feels that at the time of any study of an observation on overlap between two species, the competition and displacement may already have occurred, and would not take into account probable previous overlap. Colwell and Futuyma (1971) have similar arguments and feel that overlap could indicate both, lack of competition (when resources are abundant) and competition (when displacement or exclusion are not complete). To avoid such problems the fundamental and realised niches have to be studied and compared before arriving at any conclusion. (Hurlbert 1978, Colwell, Futuyma 1971).

With these arguments in mind I began data collection, understanding that my results may help in the formulation of a subsequent more detailed analysis of competition and overlap, but that they would not fully explain these complex community relationships.

5.2 METHODS

For detailed studies on lesser carnivores all workers have stressed the necessity to use radio telemetry. Due to reasons given in Chapter 3 such methods could not be applied for this study.

Literature releaved that both the cat species are elusive and rare but discussions with biologists (Johnsingh, Chundawat and Vijayan pers. commun) suggested that the carnivore populations (jungle cat, fishing cat and jackal) within Keoladeo National Park were high. Therefore, I used three methods for locating the carniovres :

1. Line transects
2. Searches

3. Casual encounters

5.2.1 **Line transects** : I assumed that the line transect method used for estimating relative densities could be experimented with the small carnivores.

However the transects were fixed and the animals if territorial or with small discrete home ranges may not be encountered on the few transects established. This was the probable reason for the very low number of sightings obtained on transects (jungle cat 3, fishing cat 2, jackal 10) and so no density estimates could be made. These transects were discontinued from July.

5.2.2 **Searches** : This method was used to increase encounters as they involved more intensive and more flexible search patterns than the line transects. Encounters of carnivores on searches although higher than transects for jungle cat and jackal were still too low (jungle cat 11, jackal 18) to obtain adequate results on habitat occupance , time of activity and relative abundances.

5.2.3 **Casual encounters** were also recorded as sightings. Since the other two methods did not give enough data. These encounters were higher than transects and search encounters combined (Table 13)

Casual encounters for fishing cat were very high (32) when compared to transect and search data (2). Casual encounters for jackals were also high (98). Encounters carnivores, from the three methods were combined to increase data. However after 1205 hrs of search during the 6 months in all habitats the total

sightings (transect, search, casual encounters combined) were very low, especially for the cat species (jungle cat 28, fishing cat 34).

I therefore, conclude that the three methods employed in this study are not suitable for estimating densitites or studying any ecological parameter of lesser carnivores, and do not recommend it for further studies on lesser carnivores. It is possible that casual reports of high carnivore abundance in Keoladeo were influenced by repetitive sightings of few localised and tamer individuals at favoured seasons.

For estimating absolute prey densities trapping and marking are necessary. These methods could not be applied for a short term study. Hence prey abundances were expressed as encounter rates per kilometre.

5.2.4 Scat study :

Direct observations on lesser carnivores are not always possible or sufficient for information on their diet. Scat study is probably the best way to determine the diet of a carnivore.

Although each habitat was searched intensively for scats during summer and monsoon, very few scats were found (jungle cat 27, fishing cat 9, jackal 14) especially during the monsoon. The reasons could be that either the scats were washed away with the rains, the increase in ground cover during the monsoon concealed scats or the wetlands being flooded could not be searched.

A finer level of analysis of the various prey items found in the scats were not possible because study period was short. Certain laboratory procedures such as making histological slides

tor bones and then identifying them would require more time. I did not have access to study skins for making reference slides of hairs.

The broad categories of prey items used in the analysis could only show trends and it would not be certain if the overlap estimated is actual or due to methodological limitations.

Scat studies do not give complete information on diet. Prey species such as small amphibians and insects may not show up in scats.

5.3 RESULTS :

With the limited amount of data obtained within this study (methods discussed in Chapter 3), it is not possible to make significant biological conclusions. The following conclusions are based on trends and apparent differences within the data set.

5.3.1 Habitat :

From table 7 although jungle cats and jackals appear to be most abundant in the tall grasslands, (Jungle cat : En/hr = 0.05, jackal Er/hr = 0.15) it is based on very few sightings (one for jungle cat and three for jackal). Since the number of hours spent in the tall grasslands were also low (20 hrs) the results obtained for tall grassland are inadequate. However if the other habitats are considered then jungle cats seem to be most abundant in the wetlands (Er/hr 0.028) whereas jackals were encountered more often in the mixed forests.

Jungle cats and jackals were found in all habitats but the fishing cat sightings were restricted to the wetlands.

The results show that the jungle cat and jackals are habitat generalists whereas the fishing cat is a habitat specialist.

Otter sightings being restricted to deep pools suggests that they too are habitat specialist, of tighter niche requirements than fishing cat.

5.3.2 **Scat study :**

Results show that hair formed a major portion (73%) of jungle cat scats whereas jackal scats were chiefly composed of vegetable matter (67%). Fishing cats had relatively small but equal proportions of all prey items (hair 15%, feathers 27%, vegetation matter 18% are fish (37%).

Results obtained by applying Schoener's formula of niche overlap show a maximum dietary overlap between the two cat species (0.41). Least dietary overlap is seen amongst the jungle cat and jackal (0.33).(Table 12)

By combining the results of habitat occupance and scat study it appears that jungle cats and jackals are habitat generalists but dietary specialists.

Although otter spraints could not found casual observations show the otters diet to be fish. Literature suggests that otters feed on other small aquatic mammals as well as birds in shallow water bodies or at the edges of water pools.

When prey abundance in different habitats (Tables 5,6) is compared to scat stuay results (Table 12), the following conclusions can be made :

1. **Short grasslands** had a higher abundance of mammals than aves during summer on night searches but the opposite on morning searches. This of course fits activity patterns of most rodents

and most birds jungle cat scats found in summer in this habitat. Consisted of 97% hair and no feathers. (Since only one jackal scat was found in the short grassland it is not considered here).

2. **Wetlands** : Aves were more abundant for morning and night searches during summer. Jungle cat scats found in summer in the wetlands showed an equal proportion of mammal hair and feathers (42.27%) fishing cat scats found in summer had 7.5% hair and 21.8% feathers, most was fish scales.

Jackals scats had 17% hair and no feathers and were dominated by vegetable remains.

3. **Mixed forests** : During summer no aves were encountered in this habitat on the night searches, but they were more abundant than mammals on morning searches.

Jungle cat scats found in mixed forests during summer had 77% hair and 6% feathers. Jackal scats found in summer in this habitat had 28% hair and no feathers.

4. **Tall grasslands** : More birds were encountered than mammals during summer on morning and night searches. Only jungle cat scats were found here which contained 80% hair and 15% feathers. Although encounter rate per kilometre of mammals and aves differed in different habitats during summer jungle cat scats showed a consistantly high proportion of hair. There was a positive correlation between the encounter rates per kilometre of birds in the wetlands and the proportion of feathers found in fishing cat scats.

Jackal scats from all habitats had no bird remains but mammalian hair in small proportions were found in all scats.

These results support the scat study, suggesting jungle cats and jackals to be dietary specialists.

5.3.3 Time of activity

Results for time of activity of the three species suggest that jackals are active throughout the day whereas both the cat species are nocturnal.

Figure 6 is a two dimentional diagramatic representation of the overlap between the four species of carnivores in Keoladeo National Park with respect to two niche dimensions: habitat, and diet. Time of activity is superimposed as a third dimension. This is a model of apparent overlaps and can be explained in greater detail by reference to results of habitat occupance, time of activity and scat analysis from table .

The following conclusions are made by me :

1. Jungle cats and fishing cats show maximum dietary overlap and overlap in time of activity. Jungle cats being habitat generalists are found in a variety of habitats ranging from very wet marshy areas to dry grasslands. Fishing cats on the other hand are specialists, being restricted to wet marshy areas and at the edges of these areas. This degree of habitat separation enables them to coexist.

2. Jackals and jungle cats being habitat generalists would have high degree of special overlap but their differences in time of activity and diet (being dietary specialists) allow co-existence.

3. Superficially the fishing cat and otter appear to have greater overlap, but because of the otters ability to hunt even in deeper pools the actual overlap could be low.

5.4 BEHAVIOURAL OBSERVATIONS

Behavioural observations made during the study can be used to discuss similarities and differences in habitat occupance, time of activity and diet. Observations on jungle cat and fishing cat on 2nd June (See Appendix) show that the two species of cats in certain areas occupy the same habitat at the same time with no apparent conflict. However, conclusions cannot be drawn on this, since interspecific relations might have been established prior to my study. Waser (1980) observed the small nocturnal carnivores in Serengeti. His observations of interspecific interactions between ordwolf bat-eared fox common gennet and white tailed mongooses showed "no sign of agonistic behaviour". Some of the species even foraged within 10 meters of each other. Some of my observations on the carnivores, however, showed a definite temporal and spatial separation. Jackals and jungle cats, although seen in the same habitat, were never seen together. The jungle cat and jackal observed on 23rd May (see Appendix) were hunting at the same time but in two different blocks of the wetlands. Observations on the fishing cat and jungle cat on the canal (barrier), (PLATE 2) during the month of August showed a temporal separation. Such separation was probably maintained by visual contact and avoidance (not noticed by me) whenever one species happened to encounter the other. Temporal separation by visual contact was reported by Leyhaussen 1965) on free-ranging domestic cats. He also observed domestic cats using common undefended pathways to and from feeding areas. This could have been true for my observations, where the canal

was "the common undefended pathway". Other observations made in June (18) and August (17 and 18) on the species of cats and jackals suggests that each species has a different purpose for visiting the canal - the fishing cat to catch fish, the jungle cat to rest and hunt (rodents and logomorphs) and the jackal to drink water or cross over to the forests. Time of activity would then coincide with peak time of activity of the prey species. Moreover, if the purpose of using the same area is different, the question of competition does not arise.

On several occasions, I could make observations on the feeding behaviour of the three species. This added to the information on diet of the three species, obtained from scat analysis (June 3,10 ; July 1 ; Aug. 17). From this, I could conclude that jackals sometimes prey on ground birds, insects and even fish in the very shallow pools of water, especially in summer, and the cat species would readily feed on any smaller vertebrate and invertebrate that they can capture.

My observations on the fishing cat that came to the canal to fish, suggested that a considerable amount of time may be spent capturing a fish. The cat, on occasions, waited 3-5 hours, shifting locations several times until it finally caught a fish. Possibly my presence would have distracted it too some extent.

From the behavioural observations, the following conclusions can be made :

1. Interspecific relationships probably were established prior to my observations. Hence it was difficult to observe conflict. However, certain level of tolerance and avoidance by visual contact were observed.

2. In some commonly used areas temporal separation between the three species was observed.

3. A variety of small prey not indicated by the scat analysis are eaten by all three species.

4. Considering the amount of time a fishing cat spends trying to catch fish, and from scat analysis results, fish seems to be a major and preferred food item of this cat. From observations on its hunting, it appeared that it is an opportunistic feeder on amphibians (frogs), and probably on birds and smaller mammals but seems to have a preference for fish.

5. There does not seem to be any competition from the other wild lesser carnivores (toddy cat and two species of mongooses) found in the Park. The toddy cat being chiefly a frugivore, and the mongoose being much smaller than the three species of carnivores I studied, its prey would be limited to the small vertebrates and invertebrates.

Feral dogs (Canis familiaris) and feral cat (Felis sylvestris cattus) seem to be the only two other carnivore species which could compete with my study species. However, feral cats appeared to be temporally separated from the jungle cat and fishing cat at the canal near the barrier (Appendix July 19).

5.5 JACKAL POPULATION ESTIMATES

By combining the average number of parks heard howling in the various habitats and the average litter size of jackals in the Park from May to October an approximate estimation of jackal numbers have been made. The average range of jackal populations

within the 29 km^2 is 76.24 to 133.56 individuals. This relatively large number can be due to jackals being more oppurtunistic feeders than the cats which are rare.

5.6 MANAGEMENT IMPLICATIONS

Here I discuss only about the otter and the fishing cat whose status in the country is much more precarious than those of the jackal and jungle cat.

It is obvious from the results and observations that the fishing cat and other are restricted to the wetlands. The wetlands however are highly disturbed due to several reasons given in Chapter-II (Section on disturbance). Certain management practices such as bull dozing and removal of grass and vegetation at the edges of the wetlands could cause considerable disturbance to these two species. Literature suggests that the fishing cat lives in dense located in dense vegetation at the edge of some aquatic or marshy area and the otter is found in deep pools with dens located close to dense vegetation. The presence of people such as grass cutters by itself is a disturbance. This is probably the reason why many of my fishing cat observations were at Kadam Kunj, a relatively undisturbed area. Being too far for tourists to visit and the remains of the old fort forming a good shelter this place seems to be a good refuge for the fishing cat which is a shy animal.

Bharatpur is a dry place prone to droughts. Therefore, the most difficult season for these two water dependent species is summer. Not much can be done about water being limiting since it is natural for this area and so the population of these species

will always be low in this region. However, these low populations should be protected and one way of doing this is by reducing disturbance and preserving the habitat (dense bushes around the edge of water) of these species within the Park.

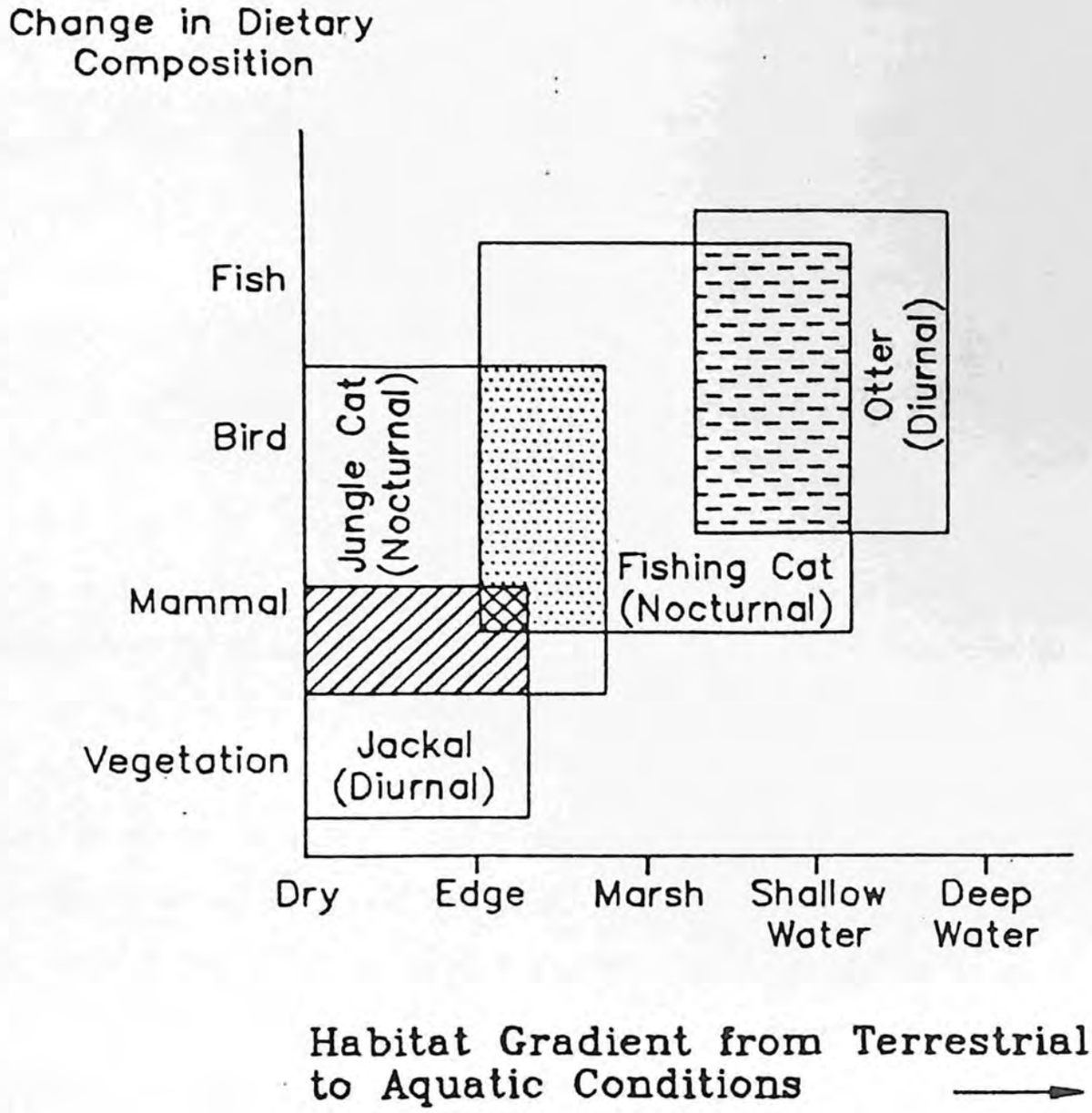


Fig. 6 A diagramatic model of over
between four sympatric carnivores
Keoladeo Ghana National Park based
three niche dimensions: habitat die
and time of activity

TABLE 13

HOURS AND DAYS SPENT IN THE FIELD, SUMMARY OF SIGHTINGS AND SCATS COLLECTED OF DIFFERENT CARNIVORES DURING THE STUDY (MAY - OCT 1989) IN KEOLADEO NATIONAL PARK, INDIA.

MONTH	FIELD DAYS	HOURS SPENT	JUNGLE CAT			FISHING CAT			JACKAL			TOTAL SIGHTINGS
			SCATS	SEARCH ENCOUNTER	CASUAL ENCOUNTER	SCATS	SEARCH ENCOUNTER	CASUAL ENCOUNTER	SCATS	SEARCH ENCOUNTER	CASUAL ENCOUNTER	
MAY	25	200	14	1	6	6	2	1	10	4	34	48
JUNE	30	225	12	6	7	2	0	3	4	4	30	50
JULY	31	220	0	4	1	0	0	3	0	13	7	28
AUGUST	31	240	1	3	0	0	0	25	0	3	15	46
SEPTEMBER	30	240	0	0	0	0	0	0	0	4	4	8
OCTOBER	9	80	0	0	0	1	0	0	0	0	8	8
TOTAL	156	1205	27	14	14	9	2	32	14	26	98	

Plate 2. Canal at barrier: visited by the three sympatric species

CHAPTER - VI

CONCLUSION

From the results and discussions the following conclusions could be made :

1. Jackals and jungle cats are habitat generalists but dietary specialists. The fishing cat is a habitat as well as dietry specialist. Similarly the otter is a habitat and dietary specialist.

2. Jungle cats and fishing cats are largely nocturnal whereas the jackal and otter could be active even through out the day.

These conclusions show that although some amount of overlap is present between these four sympatric species an overall difference in habitat occupance, time of activity and dietary composition enable them to coexist.

Sufficient data could not be obtained on line transects and searches and so these methods are not recommended for future studies on lesser carnivores.

Information obtained on behavioural observations have not only supported the results but also have given additional clue to their ecological separation.

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APPENDIX

EXCERPTS FROM FIELD DIARY (MAY - OCTOBER)

11th May 1989
1830 hrs.

"Left for Keoladeo temple for a quick round. At 1838 hrs saw two jackal pups (seen previously) near the pile of sand. They were running around the sand pile. As I approached them, they ran into the bushes near the temple. I went over to inspect the sand and got the stench of rotting meat. Greenflies had gathered at two places and after driving them away, I could see two large chunks of meat on the sand. The pups had probably been eating them.

The meat may have been part of a Nilgai carcass lying near the temple last evening".

19th May 1989
2200 hrs.

"I was sitting on the cement wall next to the sluice gate inside Sapan Mori, when suddenly, there was a splash in the water (canal). On shining the torch, I could see a lot of movement in the water and then the head of an otter sticking out. It immediately dived back into the water and was out of sight".

22nd May 1989
1800 hrs.

"Two otters sighted in the same canal at Sapan Mori, near the sluice gate. They were resting at the edge of the canal. On seeing me they dived into the water with a loud splash.

17th August 1989
1945 hrs.

"I had been waiting at the canal from 1930 hrs. The fishing cat came to the canal at around 1945 hrs and sat at the edge of the water. It looked around for some time and pounced on a frog that was just entering the water. It ate it up, It moved to another spot and sat there concentrating hard in the water. It kept changing the location approximately every 15 minutes but was not able to catch any fish. Then finally at 2430 hrs. it sprang up in the air and dived in the water. It started thrashing around (the fish ??) with its forelimbs. Then it calmed down, swam around in the water for some time (one minute), went back to where it thrashed around, immersed its head in the water, lifted out something (Could not see what it was ?) and ran onto the bank. I could not see it after that. Since it was a moonlit night I did not use my flashlight as it could have disturbed the cat".

18th August
1830 hrs.

"Two jackals seen walking on the canal towards the mixed forests."

I had no cat sightings in September and the days in October.

SPEARMAN'S RANK TEST : FORMULA

$$r_s = 1 - \frac{6 \sum^{n} di^2}{N^3 - N}$$

Where di = differences in ranks of prey items in Jungle cat scats from Wetlands and Short grasslands.

N = Total number of prey items

MANN - WHITNEY - U TEST : FORMULAE

$$U = n_1 n_2 + \frac{n_1 (n_1 + 1)}{2} - R_1 \quad \ldots\ldots\ldots (1)$$

$$U = n_1 n_2 + \frac{n_2 (n_2 + 1)}{2} - R_2 \quad \ldots\ldots\ldots (2)$$

Where n_1 = number of scats in short grasslands.

n_2 = number of scats in wetlands.

R_1 = summation of ranks for hair and feathers (seperately) in short grasslands.

R_2 = summation of ranks for hair and feathers (separately) in wetlands.

From equations 1 and 2, U having a smaller value was chosen.