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)

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CONTENTS

CHAPTER I : INTRODUCTION ................................. 1
1.1 JUSTIFICATION ................................. 1
1.2 REVIEW OF LITERATURE ....................... 2
1.3 HYPOTHESIS .................................. 5
1.4 OBJECTIVES .................................. 5

CHAPTER II : STUDY AREA ................................. 7
2.1 LOCATION .................................... 7
2.2 AREA AND TOPOGRAPHY ....................... 7
2.3 CLIMATE .................................. 7
2.4 FAUNA .................................... 7
2.5 VEGETATION ................................ 8

2.5.1 WETLANDS ................................ 9
2.5.2 SHORT GRASSLANDS .................... 10
2.5.3 TALL GRASSLANDS ...................... 11
2.5.4 MIXED FORESTS ......................... 11

2.6 DISTURBANCE ................................. 12

FIGURE 1 .................................. 13
FIGURE 2 .................................. 14
FIGURE 3 .................................. 15

PLATE 1 .................................. 16

CHAPTER III : METHODS ................................. 17
3.1 FIELD METHODS ................................. 17

3.1.1 LINE TRANSECTS ....................... 18
3.1.2 SEARCHES ................................ 19
3.1.3 SCAT COLLECTION ..................... 19
3.1.4 BEHAVIOURAL OBSERVATIONS 20
3.1.5 ESTIMATION OF JACKAL NUMBERS -

HOwl COUNTS ....................... 20

3.2 ANALYTICAL METHODS ......................... 21

3.2.1 PREY ABUNDANCE ....................... 21
3.2.2 HABITAT OCCUPANCE ................... 21
3.2.3 TIME OF ACTIVITY ..................... 22
3.2.4 SCAT ANALYSIS ......................... 22

FIGURE 4 .................................. 24
TABLE 1 .................................................. 25
TABLE 2 .................................................. 25
TABLE 3 .................................................. 26
TABLE 4 .................................................. 27
TABLE 5 .................................................. 28
TABLE 6 .................................................. 29
TABLE 7 .................................................. 30
TABLE 8 .................................................. 31
TABLE 9 a .................................................. 32
TABLE 9 b .................................................. 33
TABLE 9 c .................................................. 34
TABLE 9 d .................................................. 35
TABLE 10 .................................................. 36
TABLE 11 .................................................. 37
TABLE 12 .................................................. 38

CHAPTER IV : RESULTS .................................................. 39

4.1 INTRODUCTION ........................................ 39
4.2 INFORMATION COLLECTED : LIMITATIONS OF THE STUDY ........... 39

4.3 PREY ABUNDANCE ........................................ 40
4.3.1 NIGHT SEARCHES ..................................... 40
4.3.2 MORNING SEARCHES ................................... 42

4.4 HABITAT OCCUPANCE .................................... 43
4.5 TIME OF ACTIVITY ....................................... 44
4.6 SCAT ANALYSIS ........................................... 44
4.7 JACKAL PACK NUMBERS BY HOWL COUNTS 46

FIGURE 5 .................................................. 47

CHAPTER V : DISCUSSION ........................................ 48

5.1 INTRODUCTION ........................................... 48
5.1.1 HABITAT AND NICHIE .............................. 48
5.1.2 NICHE OVERLAP AND COMPETITION ............... 49

5.2 METHODS ................................................. 51
5.2.1 LINE TRANSECTS ..................................... 52
5.2.2 SEARCHES ............................................. 52
5.2.3 CASUAL ENCOUNTERS .............................. 52
5.2.4 SCAT STUDY .......................................... 53

5.3 RESULTS .................................................. 54
5.3.1 HABITAT ................................................. 54
5.3.2 SCAT STUDY ........................................... 54
5.3.3 TIME OF ACTIVITY .................................... 57
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 perplicillata*).

Objectives of the study were to determine differences in dietary composition, habitat occupancy 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.
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CHAPTER 1

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 (Johnsingh 1986) and any protected area would have more than three lesser carnivores. In spite 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 km²) 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 occupancy 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 (Pris viverrina benneti)

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* Goldstaedt)

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 up to 6 young at a time in dens which are usually abandoned burrows. However, usual litter size is three (Ricciuti 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 perspiculata*)

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 occupancy 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° 7.6' and 27° 12.2'N latitude and 76° 29.5' and 77° 33.9'E longitude, 2 kms. S.E. of Bharatpur city. It is surrounded on all sides by 14 villages and agricultural land. A masonry 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 km². 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°C in winter to a maximum of 48°C in summer (B.N.H.S. 1986). “The mean minimum temperature between 1982-1985 was 6°C as recorded in January 1984 and February 1985. The mean maximum was 48°C 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 squirrel (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

Gaus sen 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 philomoides*. (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 Chana 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 NW form a major portion of the wetlands. Earthen 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 (e.g., 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 *Prosopis cineraria* trees are also scattered in the wetlands (Perennou and Ramesh 1987).

### 2.5.2 Short grasslands

Blocks K, L 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, Salvadoria 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, Syzygium cumini and saline
zone associations like Prosopis juliflora, Salvadoria 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. 2. The four major habitat types in 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 lesser carnivores involved tagging (Robinson and Grand 1956) 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 km² (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 rechargeable 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 identify 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 up to a minimum distance of 2 mts. and jackals up to 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 occupancy 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 dietary 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. Schuener's niche overlap index (1970) was used to measure overlap from the final proportions of the prey items.

\[ O_{xy} = 1 - 0.5 \left( \sum |X_i - Y_i| \right) \]

\( P_{xi} \) = Proportion of species \( x \) using resource \( i \).

\( P_{yi} \) = 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, BHRATPUR

Scale 1:37000

[Map depicting line transects in the four major habitats of Keoladeo National Park, Bharatpur.]
Table-1: Area and length of transects in different vegetation types.

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<thead>
<tr>
<th>HABITAT</th>
<th>AREA</th>
<th>TRANSECT LENGTH</th>
<th>NO. OF TRANSECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetland</td>
<td>10.5 sq.km.</td>
<td>2 km</td>
<td>2</td>
</tr>
<tr>
<td>Short grassland</td>
<td>6.0 sq.km.</td>
<td>2 km</td>
<td>1</td>
</tr>
<tr>
<td>Tall grassland</td>
<td>6.5 sq.km.</td>
<td>2 km</td>
<td>1</td>
</tr>
<tr>
<td>Mixed Forest</td>
<td>3.5 sq.km.</td>
<td>1 km</td>
<td>1</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>HABITAT</th>
<th>MORNING</th>
<th>NIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SUMMER</td>
<td>MONSOON</td>
</tr>
<tr>
<td></td>
<td>TIME</td>
<td>DIST.</td>
</tr>
<tr>
<td>Wetlands</td>
<td>4 hrs.</td>
<td>8 kms.</td>
</tr>
<tr>
<td>Short-grasslands</td>
<td>2 hrs.</td>
<td>4 kms.</td>
</tr>
<tr>
<td>Tall-grasslands</td>
<td>2 hrs.</td>
<td>4 kms.</td>
</tr>
<tr>
<td>Mixed Forest</td>
<td>1 hr.</td>
<td>2 kms.</td>
</tr>
</tbody>
</table>
Table 3: Time spent and distance covered in different habitat types in different times by searches in summer and monsoon.

### A - SUMMER

<table>
<thead>
<tr>
<th>HABITAT</th>
<th>MORNING</th>
<th></th>
<th></th>
<th>NIGHT</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TIME</td>
<td>DIST.</td>
<td>TIME</td>
<td>DIST.</td>
<td></td>
</tr>
<tr>
<td>Wetlands</td>
<td>4 hrs.</td>
<td>8 kms.</td>
<td>6 hrs.</td>
<td>12 kms.</td>
<td></td>
</tr>
<tr>
<td>Short grasslands</td>
<td>2 hrs.</td>
<td>4 kms.</td>
<td>3 hrs.</td>
<td>6 kms.</td>
<td></td>
</tr>
<tr>
<td>Tall grasslands</td>
<td>2 hrs.</td>
<td>4 kms.</td>
<td>3 hrs.</td>
<td>6 kms.</td>
<td></td>
</tr>
<tr>
<td>Mixed forest</td>
<td>1 hr.</td>
<td>2 kms.</td>
<td>1.5 hrs.</td>
<td>3 kms.</td>
<td></td>
</tr>
</tbody>
</table>

### B - MONSOON

<table>
<thead>
<tr>
<th>HABITAT</th>
<th>MORNING</th>
<th></th>
<th></th>
<th>NIGHT</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TIME</td>
<td>DIST.</td>
<td>TIME</td>
<td>DIST.</td>
<td></td>
</tr>
<tr>
<td>Wetlands</td>
<td>4 hrs.</td>
<td>8 kms.</td>
<td>20 hrs.</td>
<td>40 kms.</td>
<td></td>
</tr>
<tr>
<td>Short grasslands</td>
<td>2 hrs.</td>
<td>4 kms.</td>
<td>10 hrs.</td>
<td>20 kms.</td>
<td></td>
</tr>
<tr>
<td>Tall grasslands</td>
<td>-</td>
<td>-</td>
<td>1 hrs.</td>
<td>2 kms.</td>
<td></td>
</tr>
<tr>
<td>Mixed forest</td>
<td>1 hr.</td>
<td>2 kms.</td>
<td>5 hrs.</td>
<td>10 kms.</td>
<td></td>
</tr>
</tbody>
</table>
**Table 4.**

Estimation of Jackal Populations in Keoladeo National Park (May - October, 1982).

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Blocks</th>
<th>No. of Packs Heard Howling Range</th>
<th>x Packs Heard</th>
<th>Mean Litter Size</th>
<th>Av. No. of Jackals (and No. of litters for W.D. stands)</th>
<th>Total</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetland</td>
<td>L</td>
<td>2-3</td>
<td>2.30</td>
<td>3.18</td>
<td>12.62</td>
<td>42.6</td>
<td>12.72-19.08</td>
</tr>
<tr>
<td>Wetland</td>
<td>E &amp; D</td>
<td>1-3</td>
<td>2.00</td>
<td>3.18</td>
<td>12.72</td>
<td>42.6</td>
<td>6.36-19.08</td>
</tr>
<tr>
<td>Wetland</td>
<td>LW</td>
<td>2-3</td>
<td>2.40</td>
<td>3.18</td>
<td>15.26</td>
<td>42.6</td>
<td>12.72-19.08</td>
</tr>
<tr>
<td>Short Grassland</td>
<td>J, K, M.</td>
<td>1-3</td>
<td>1.80</td>
<td>3.18</td>
<td>11.44</td>
<td>36.3</td>
<td>6.36-19.08</td>
</tr>
<tr>
<td>Mixed Forest</td>
<td>A &amp; M</td>
<td>1-2</td>
<td>1.25</td>
<td>3.18</td>
<td>7.95</td>
<td>23.85</td>
<td>6.36 - 12.72</td>
</tr>
<tr>
<td>Mixed Forest</td>
<td>B &amp; N</td>
<td>1-2</td>
<td>1.00</td>
<td>3.18</td>
<td>6.36</td>
<td>23.85</td>
<td>6.36 - 12.72</td>
</tr>
<tr>
<td>Mixed Forest</td>
<td>C</td>
<td>1-2</td>
<td>1.50</td>
<td>3.18</td>
<td>9.54</td>
<td>23.85</td>
<td>6.36 - 12.72</td>
</tr>
<tr>
<td><strong>Total Population Range</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>76.24 - 133.56</strong> in 20 km²</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: In the tall grasslands no packs were heard howling but at least three packs are present. Therefore, average number of Jackals in tall grasslands are 19.08.
## Table 5.

Prey abundance in the various habitats of Kgalagadi National Park on morning searches.

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Total Time Effort</th>
<th>Distance Moved / Section (km)</th>
<th>No of Transsections</th>
<th>Mammals *</th>
<th>Aves **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetlands Summer</td>
<td>8 hr</td>
<td>16 km</td>
<td>8</td>
<td>1.03</td>
<td>20</td>
</tr>
<tr>
<td>Monsoon</td>
<td>8 hr</td>
<td>16 km</td>
<td>8</td>
<td>1.12</td>
<td>20</td>
</tr>
<tr>
<td>Short Grassland</td>
<td>4 hr</td>
<td>8 km</td>
<td>4</td>
<td>0.62</td>
<td>10</td>
</tr>
<tr>
<td>Monsoon</td>
<td>4 hr</td>
<td>8 km</td>
<td>4</td>
<td>1.75</td>
<td>10</td>
</tr>
<tr>
<td>Tall Grassland</td>
<td>4 hr</td>
<td>8 km</td>
<td>4</td>
<td>0</td>
<td>9.50</td>
</tr>
<tr>
<td>Mixed Forest</td>
<td>2 hr</td>
<td>4 km</td>
<td>4</td>
<td>1.25</td>
<td>10</td>
</tr>
<tr>
<td>Monsoon</td>
<td>2 hr</td>
<td>4 km</td>
<td>4</td>
<td>1.75</td>
<td>10</td>
</tr>
</tbody>
</table>

\* Encounter rate per kilometre.
\*\* Maximum sighting distance in metres.
### Table 6: Prey Abundance in the Various Habitats of Keoladeo National Park on Night Searches

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetlands Summer</td>
<td>10 HR 20 KM 10</td>
<td>2.35</td>
<td>10</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>Monsoon</td>
<td>20 HR 40 KM 20</td>
<td>2.85</td>
<td>10</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>Short Grassland Summer</td>
<td>10 HR 20 KM 10</td>
<td>2.20</td>
<td>10</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>Monsoon</td>
<td>10 HR 20 KM 10</td>
<td>2.35</td>
<td>10</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>Tall Grassland Summer</td>
<td>10 HR 20 KM 10</td>
<td>2.20</td>
<td>10</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>Monsoon</td>
<td>10 HR 20 KM 10</td>
<td>2.35</td>
<td>10</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>Mixed Forest Summer</td>
<td>24 HR 30 KM 10</td>
<td>2.60</td>
<td>10</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>Monsoon</td>
<td>5 HR 10 KM 10</td>
<td>1.50</td>
<td>10</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td></td>
</tr>
</tbody>
</table>

* Encountered Rate per Kilometre.

** Maximum Sighting Distance in Metres.
<table>
<thead>
<tr>
<th>SPECIES</th>
<th>N</th>
<th>AVERAGE</th>
<th>WETLAND</th>
<th>TALL GRASSLAND</th>
<th>SHRUB GRASSLAND</th>
<th>MIXED FOREST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>E&lt;sub&gt;a&lt;/sub&gt;</td>
<td>n</td>
<td>E&lt;sub&gt;r&lt;/sub&gt;</td>
<td>n</td>
<td>E&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>JUNGLE CAT</td>
<td>28</td>
<td>0.0265</td>
<td>21</td>
<td>0.028</td>
<td>1</td>
<td>0.05</td>
</tr>
<tr>
<td>FISHING CAT</td>
<td>34</td>
<td>0.0115</td>
<td>34</td>
<td>0.046</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>JACKAL</td>
<td>12</td>
<td>0.105</td>
<td>77</td>
<td>0.105</td>
<td>3</td>
<td>0.15</td>
</tr>
<tr>
<td>TOTAL</td>
<td>132</td>
<td></td>
<td>132</td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>APPROX NO. OF HRS SPENT</td>
<td></td>
<td></td>
<td>730</td>
<td>20</td>
<td>110</td>
<td>345</td>
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</tbody>
</table>
## Table 8

**Time of Activity of Three Carnivores, Kekadeo National Park.**

<table>
<thead>
<tr>
<th>Species</th>
<th>$N_1$</th>
<th>5:30 AM - 9:30 AM</th>
<th>9:30 AM - 12:30 AM</th>
<th>12:30 AM - 3:30 PM</th>
<th>3:30 PM - 6:30 PM</th>
<th>6:30 PM - 9:30 PM</th>
<th>9:30 PM - 12:30 AM</th>
<th>12:30 AM - 3:30 AM</th>
<th>3:30 AM - 6:30 AM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jungle Cat</td>
<td>28</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.09</td>
<td>0.03</td>
<td>0.10</td>
<td>0.25</td>
<td>0.083</td>
<td>0.007</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2)</td>
<td>(2)</td>
<td>(2)</td>
<td>(2)</td>
<td>(2)</td>
<td>(2)</td>
<td>(2)</td>
<td>(2)</td>
</tr>
<tr>
<td>Jackal</td>
<td>127</td>
<td>2</td>
<td>2.22</td>
<td>2.104</td>
<td>1.5</td>
<td>0.26</td>
<td>0.589</td>
<td>0.8</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
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<td>(2)</td>
<td>(2)</td>
<td>(2)</td>
<td>(2)</td>
<td>(2)</td>
<td>(2)</td>
<td>(2)</td>
<td>(2)</td>
</tr>
<tr>
<td>Fishing Cat</td>
<td>34</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td></td>
<td></td>
<td>0.07</td>
<td>0.13</td>
<td>0.16</td>
<td>0.112</td>
<td>0.23</td>
<td>0</td>
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<td>(2)</td>
<td>(2)</td>
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<td>(2)</td>
<td>(2)</td>
<td>(2)</td>
<td>(2)</td>
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<tr>
<td>$N_2$</td>
<td>23</td>
<td>2</td>
<td>13</td>
<td>16</td>
<td>112</td>
<td>23</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.96</td>
<td>3.53</td>
<td>6.08</td>
<td>3.01</td>
<td>3.00</td>
<td>3.00</td>
<td>1.92</td>
<td>0.92</td>
</tr>
<tr>
<td>Approx. Hrs.</td>
<td>240 Hrs.</td>
<td>90 Hrs.</td>
<td>125 Hrs.</td>
<td>60 Hrs.</td>
<td>300 Hrs.</td>
<td>300 Hrs.</td>
<td>90 Hrs.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$N_1$: Total Sightings for each species.

$N_2$: Total Sightings of three species in each time class.
<table>
<thead>
<tr>
<th>DATE</th>
<th>HAIR</th>
<th>BONES</th>
<th>FEATHERS</th>
<th>FISH</th>
<th>INSECTS</th>
<th>VEGETABLE MATERIAL</th>
<th>OTHERS</th>
</tr>
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<tbody>
<tr>
<td>May 21st</td>
<td>95%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5%</td>
<td>0</td>
</tr>
<tr>
<td>May 28th</td>
<td>100%</td>
<td>TRACE</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>TRACE</td>
<td>0</td>
</tr>
<tr>
<td>June 23rd</td>
<td>45%</td>
<td>5%</td>
<td>45%</td>
<td>5%</td>
<td>0</td>
<td>TRACE</td>
<td>0</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>80%</td>
<td>1.66%</td>
<td>15.0%</td>
<td>1.66%</td>
<td>0</td>
<td>1.66%</td>
<td>0</td>
</tr>
<tr>
<td>DATE</td>
<td>PLACE</td>
<td>PREY</td>
<td>TRACES</td>
<td>HAIR</td>
<td>BONES</td>
<td>FEATHER</td>
<td>FISH</td>
</tr>
<tr>
<td>---------</td>
<td>----------------</td>
<td>------</td>
<td>--------</td>
<td>------</td>
<td>-------</td>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>MAY 20th</td>
<td>SAPAN MORI</td>
<td>45%</td>
<td>10%</td>
<td>45%</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MAY 21st</td>
<td>SAPAN MORI</td>
<td>45%</td>
<td>10%</td>
<td>45%</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MAY 22nd</td>
<td>SAPAN MORI</td>
<td>40%</td>
<td>0</td>
<td>60%</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MAY 23rd</td>
<td>BAKALYA</td>
<td>90%</td>
<td>5%</td>
<td>0</td>
<td>TRACE</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MAY 24th</td>
<td>BAKALYA</td>
<td>95%</td>
<td>5%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MAY 25th</td>
<td>BAKALYA</td>
<td>90%</td>
<td>5%</td>
<td>0</td>
<td>TRACE</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>JUNE 2nd</td>
<td>BEHIND SHORT GRASS</td>
<td>5%</td>
<td>40%</td>
<td>5%</td>
<td>0</td>
<td>TRACE</td>
<td>0</td>
</tr>
<tr>
<td>JUNE 3rd</td>
<td>KRAM KINT</td>
<td>0</td>
<td>5%</td>
<td>95%</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>JUNE 4th</td>
<td>KRAM KINT</td>
<td>10%</td>
<td>50%</td>
<td>20%</td>
<td>50%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>JUNE 5th</td>
<td>KRAM KINT</td>
<td>0</td>
<td>0</td>
<td>100%</td>
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<td>0</td>
</tr>
<tr>
<td>JUNE 6th</td>
<td>KRAM KINT</td>
<td>0</td>
<td>5%</td>
<td>95%</td>
<td>TRACE</td>
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</tr>
<tr>
<td>AVERAGE</td>
<td></td>
<td>42.2%</td>
<td>12%</td>
<td>42.2%</td>
<td>2.0%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Date</td>
<td>Place</td>
<td>Hair</td>
<td>Bones</td>
<td>Feathers</td>
<td>Fish</td>
<td>Insects</td>
<td>Vegetation</td>
</tr>
<tr>
<td>----------</td>
<td>---------</td>
<td>-------</td>
<td>-------</td>
<td>----------</td>
<td>------</td>
<td>---------</td>
<td>------------</td>
</tr>
<tr>
<td>May 6th</td>
<td>Lala Pima</td>
<td>100%</td>
<td>Trace</td>
<td>0</td>
<td>0</td>
<td>Trace</td>
<td>Trace</td>
</tr>
<tr>
<td>May 6th</td>
<td>Lala Pima</td>
<td>100%</td>
<td>Trace</td>
<td>0</td>
<td>0</td>
<td>Trace</td>
<td>Trace</td>
</tr>
<tr>
<td>May 25th</td>
<td>Trail 3</td>
<td>90%</td>
<td>10%</td>
<td>Trace</td>
<td>0</td>
<td>0</td>
<td>Trace</td>
</tr>
<tr>
<td>May 25th</td>
<td>Trail 3</td>
<td>95%</td>
<td>5%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>May 26th</td>
<td>Trail 3</td>
<td>95%</td>
<td>5%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>June 24th</td>
<td>Trail 3</td>
<td>100%</td>
<td>Trace</td>
<td>Trace</td>
<td>0</td>
<td>0</td>
<td>Trace</td>
</tr>
<tr>
<td>June 24th</td>
<td>Trail 3</td>
<td>100%</td>
<td>Trace</td>
<td>Trace</td>
<td>0</td>
<td>0</td>
<td>Trace</td>
</tr>
<tr>
<td>Average</td>
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<td>0</td>
<td>0</td>
</tr>
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<td>PREY ITEMS</td>
<td>HAIR</td>
<td>BONES</td>
<td>FEATHERS</td>
<td>FISH</td>
<td>INSECTS</td>
<td>YEASTING MATERIAL</td>
<td>OTHERS</td>
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<td>------------</td>
<td>------</td>
<td>-------</td>
<td>----------</td>
<td>------</td>
<td>---------</td>
<td>-------------------</td>
<td>-------</td>
</tr>
<tr>
<td>MAY 23rd</td>
<td>100%</td>
<td>TRACE</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>JUNE 1st</td>
<td>90%</td>
<td>5%</td>
<td>TRACE</td>
<td>TRACE</td>
<td>0</td>
<td>0</td>
<td>TRACE</td>
</tr>
<tr>
<td>JUNE 14th</td>
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<td>5%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>JUNE 16th</td>
<td>35%</td>
<td>60%</td>
<td>0</td>
<td>0</td>
<td>5%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>JUNE 23rd</td>
<td>65%</td>
<td>5%</td>
<td>30%</td>
<td>0</td>
<td>0</td>
<td>TRACE</td>
<td>0</td>
</tr>
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<td>AUGUST 8th</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>63%</td>
<td>83%</td>
<td>20-33%</td>
<td>5-10%</td>
<td>0.33%</td>
<td>0.33%</td>
<td>1%</td>
</tr>
</tbody>
</table>

TABLE 9(a): JUNGLE CAT SCAT ANALYSIS - MIXED FORESTS [n=6]
TABLE 10.
JACKAL SCAT ANALYSIS – SUMMER AND MONSOON

<table>
<thead>
<tr>
<th>DATE</th>
<th>PLACE FROM</th>
<th>HVR</th>
<th>BONES</th>
<th>FEATHERS</th>
<th>FISH</th>
<th>INSECTS</th>
<th>VEGETABLE MATERIAL</th>
<th>SEEDS</th>
<th>GRASS</th>
<th>OTHERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 16th</td>
<td>Wetlands</td>
<td>Trace</td>
<td>Trace</td>
<td>Trace</td>
<td>Trace</td>
<td>10</td>
<td>90</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May 16th</td>
<td></td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>90</td>
<td>0</td>
</tr>
<tr>
<td>May 25th</td>
<td></td>
<td>70</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>June 2nd</td>
<td></td>
<td>Trace</td>
<td>0</td>
<td>Trace</td>
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<td>10</td>
<td>90</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June 2nd</td>
<td></td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May 3rd</td>
<td>Mixed</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>90</td>
<td>10</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>May 20th</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>May 21st</td>
<td></td>
<td>40</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>60</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>May 21st</td>
<td></td>
<td>50</td>
<td>0</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>May 21st</td>
<td></td>
<td>50</td>
<td>Trace</td>
<td>0</td>
<td>Trace</td>
<td>20</td>
<td>30</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June 1st</td>
<td>Wetlands</td>
<td>Trace</td>
<td>Trace</td>
<td>Trace</td>
<td>Trace</td>
<td>0</td>
<td>Trace</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>May 28th</td>
<td>Tall Grass</td>
<td>80</td>
<td>Trace</td>
<td>Trace</td>
<td>Trace</td>
<td>0</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>May 28th</td>
<td></td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>95</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>June 25th</td>
<td>Shortsgrass</td>
<td>95</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>27</td>
<td>2.8</td>
<td>0.91</td>
<td>0.71</td>
<td>1.25</td>
<td>5.6</td>
<td>5.3</td>
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</table>
## Table II.

**Fishing Cat Scat Analysis**

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Place</th>
<th>Hair</th>
<th>Bones</th>
<th>Feathers</th>
<th>Fish</th>
<th>Insects</th>
<th>Vegetable Material</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>May 10th</td>
<td>Kadamkunt</td>
<td>5%</td>
<td>10%</td>
<td>95%</td>
<td>Trace</td>
<td>O</td>
<td>Trace</td>
<td>O</td>
</tr>
<tr>
<td>2.</td>
<td>May 15th</td>
<td>Kadamkunt</td>
<td>5%</td>
<td>20%</td>
<td>5%</td>
<td>15%</td>
<td>O</td>
<td>50%</td>
<td>5%</td>
</tr>
<tr>
<td>3.</td>
<td>May 18th</td>
<td>Kadamkunt</td>
<td>10%</td>
<td>25%</td>
<td>Trace</td>
<td>25%</td>
<td>5%</td>
<td>30%</td>
<td>Trace</td>
</tr>
<tr>
<td>4.</td>
<td>May 18th</td>
<td>Kadamkunt</td>
<td>10%</td>
<td>60%</td>
<td>O</td>
<td>20%</td>
<td>O</td>
<td>10%</td>
<td>Trace</td>
</tr>
<tr>
<td>5.</td>
<td>May 19th</td>
<td>Kadamkunt</td>
<td>Trace</td>
<td>45%</td>
<td>O</td>
<td>50%</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>6.</td>
<td>May 20th</td>
<td>Bison Mili</td>
<td>10%</td>
<td>45%</td>
<td>O</td>
<td>65%</td>
<td>Trace</td>
<td>Trace</td>
<td>O</td>
</tr>
<tr>
<td>7.</td>
<td>June 7th (A)</td>
<td>Kadamkunt</td>
<td>10%</td>
<td>10%</td>
<td>35%</td>
<td>45%</td>
<td>O</td>
<td>Trace</td>
<td>O</td>
</tr>
<tr>
<td>8.</td>
<td>June 7th (B)</td>
<td>Kadamkunt</td>
<td>10%</td>
<td>40%</td>
<td>50%</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>9.</td>
<td>Oct 1st</td>
<td>Agahpur</td>
<td>35%</td>
<td>5%</td>
<td>O</td>
<td>30%</td>
<td>Trace</td>
<td>30%</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td>AVERAGE</td>
<td></td>
<td>10.5%</td>
<td>20.8%</td>
<td>19.4%</td>
<td>20.6%</td>
<td>0.55%</td>
<td>13.3%</td>
<td>O</td>
</tr>
</tbody>
</table>
**Table 1.**

**Dietary Overlap from Scat Analysis**

<table>
<thead>
<tr>
<th>PREY ITEM SPECIES</th>
<th>HAIR</th>
<th>FEATHERS</th>
<th>FISH</th>
<th>INSECTS</th>
<th>VEGETABLE MATERIALS</th>
<th>INDEX FOR NICHE OVERLAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fishing Cat</td>
<td>0.15</td>
<td>0.27</td>
<td>0.37</td>
<td>0</td>
<td>0.18</td>
<td>0.41</td>
</tr>
<tr>
<td>Jungle Cat</td>
<td>0.73</td>
<td>0.22</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Jungle Cat</td>
<td>0.73</td>
<td>0.22</td>
<td>0</td>
<td>0</td>
<td>0.58</td>
<td>0.33</td>
</tr>
<tr>
<td>Jackal</td>
<td>0.28</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.54</td>
<td>0.37</td>
</tr>
<tr>
<td>Fishing Cat</td>
<td>0.15</td>
<td>0.27</td>
<td>0.37</td>
<td>0</td>
<td>0.18</td>
<td>0.37</td>
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</tbody>
</table>
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 occupancy, 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 dietary 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
A 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 (2.35), 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 (0.4) 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 (average 0.026).

Fishing cats were restricted to the wetlands and had an encounter rate (0.046) 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 separately insect remains were present at trace levels (< 0.05) 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).

Dietary 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 8 does show a trend towards an equal proportion of hair in wetlands habitat compared to a greater proportion of feathers 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 and 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.
5.1.2 Niche 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 Futyma (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 resource 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, Futyma 1971).

One of the most simple measure of niche overlap:

$$O_{xy} = 1 - 0.5 \left( 1P_{x_i} - P_{y_i} \right)$$

used by Schoener (1970)

where $P_{x_i}$ is the proportion of species $x$ using resource $i$ and $P_{y_i}$ 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, Futyma 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 examining niche occupancy.

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 or 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 revealed 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 carnivores:

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 occupancy, 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 (96). 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 densities 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...
for 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: Er/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 occupancy 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 study 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 suits 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 consistently 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 dimensional 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 occupancy, 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 occupancy, 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 genet 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 undetended pathways to and from feeding areas. This could have been true for my observations, where the canal
was "the common undetended 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 to 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 packs 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 km² is 76.24 to 153.56 individuals. This relatively large number can be due to jackals being more opportunistic 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 bulldozing 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 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: Diagrams show a model of relations between four sympatric species in Kibale. The National Park protects three of these species. Habitat shape and time of activity...
Fig. 6 A diagramatic model of overlap between four sympatric carnivores in Keoladeo Ghana National Park based on three niche dimensions: habitat diet and time of activity.
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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 dietary 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 throughout the day.

These conclusions show that although some amount of overlap is present between these four sympatric species an overall difference in habitat occupation, 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.
REFERENCES


11th May 1989
1830 hrs.

"Left for Keoladeo temple for a quick round. At 1818 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."
1819 hrs.

The two otters surfaced a few metres away, stared at me for around 10 seconds and dived back into the water. Could only see a lot of movement and hear loud splashes in the water, after that.

23rd May 1969
2025 hrs.

"While walking toward the barrier, at Sapan Mori an animal was seen running out of the wetlands to my right, onto the road. When it was about 20 mts away I could identify it as a jackal. It ran back into the wetlands and went stright toward a small pool of water at the corner. It ran around in the water which came upto its ankles. It was probably fishing, as fish in all water pools were exposed due to water drying up.

The jackal started beating the water with its forepaws, occasionally jumping at something. All the while the tail was held up erect. It eventually caught something (could not identify what was caught); came out of the pool and sat on a dry patch of grass. It started eating at 2035 hrs".

23rd May 1969
2115 hrs.

"While returning to the barrier from Sapan Mori, approx. 100 mts. after the bench (near Bakalaya), I got the strong smell of cat urine from the bushes at the edge of the wetlands. I flashed the torch around and approx. 20 mts. inside to my left, saw a jungle cat crouching on the ground. It suddenly sprang up in the air (like a serval) and pounced on something (frog ? insect ?). It carried the prey to one of the large mounds nearby and ate it
up. It came down again, walked toward another mound and sat in the grass for a few minutes. I could not observe what it was doing. After around 2 minutes, it walked away, behind the mound and could not be spotted again”.

29th May 1989
1830 hrs.

"Otter sighted in the Mansarover lake. It climbed onto a mound at the edge of the water but quickly slid back into the lake”.

31st May 1989
1645 hrs.

"Three jackal pups and one adult were sighted near the forest lodge. The pups were playing with the adult, close to their den (at the side of the road). They were racing madly around the adult. They probably sensed my presence, as they suddenly ran into the bushes and could not be located”.

31st May 1989
1920 hrs.

"Jungle cat seen walking near the canal in the wetlands. It saw me and hid in some bushes. A few minutes later I could see it run toward the canal, but was unable to follow it”.

2330 hrs.

"A house cat came to the canal and went down to the edge of the water for a drink. It was smaller than the jungle cat seen this evening”.

...
"On the way to Kadam Kunj in a jeep, saw a jungle cat walking on the road (Rings on tail distinct). It ran along the road with its tail held up like a flag. I turned and ran into the wetlands to the right.

2041 hrs. : Sitting upright and watching us.

2042 hrs. : Sitting relaxed with forepaws outstretched; watching us.

2042 hrs. : Sat up again, alert and watching us.

2044 hrs. : Ran away, as we approached too close”.

2105 hrs. : "Very close to Kadam Kunj on the left hand side, two fishing cats seen resting, approx. 10 m away from us. Forepaws tucked in one cat larger and darker.

2105 hrs. : Spotlight on the cats. Darker individual got up and walked away.

2110 hrs. : A jungle cat (same one seen earlier ??) walked toward us and settled down (approx. 50 m. from where we were sitting) in the beam of the spotlight, observing us.

Fishing cat (lighter individual) raised its head, saw the jungle cat ??

2111 hrs. : Jungle cat settled down completely; relaxing on its side with forepaws tucked in, facing us.

Fishing cat got up and moved closer to us or the jungle cat?

Distance between two cats was less than 50 m.

2115 hrs. - 2125 hrs. : Both the cats resting with eyes shut. Jungle cat with its forepaws tucked in, whereas the fishing cat with stretched forepaws, resting its head (stretched neck) on
2130 hrs. : Jungle cat got up and walked toward the pool of water a few metres away.

Fishing cat resting in the same position.

2135 hrs. : Fishing cat raised its head, sat watching us, with front paws still tucked in.

2140 hrs. : Fishing cat sat up and started grooming itself. It licked its flanks, back, scratched behind its ears and under its chin with its right hindpaw and continued licking itself.

2143 hrs. : Fishing cat resting again with paws tucked in and eyes shut.

2155 hrs. : Fishing cat got up and started walking toward Kadam Kunj.

2200 hrs. : After following, located it a few metres away, closer to the road. Resting with paws tucked in and eyes shut.

2205 hrs. : Jungle cat sighted again near the pool of water. Distance between the two cats approx. 100 mts. Jungle cat pounced on something (insect ? frog ?).

2206 hrs. : Jungle cat walking.

2207 hrs. : Jungle cat sitting under some bushes at the edge of water.

2208 hrs. : Jungle cat walking away.

Fishing cat sleeping.

2220 hrs. : Jungle cat came back again and sat down. Fishing cat sleeping.

2225 hrs. : Jungle cat walking away, searching on the ground ?

2230 hrs. : Jungle cat out of sight. Fishing cat sleeping.
3rd June
1645 hrs.

"Jackal sighted at Sapan Mori (near the water pool). The jackal was in the puddle of water. It suddenly came out, ran across the road onto the other block of the wetlands. I could see some bird in its mouth but could not identify the bird. I followed the jackal around 1850 hrs., it dropped the bird down, picked it up again and ran."

3rd June 1989
2115 hrs.

"On a night drive, saw a jungle cat hunting in the wetlands, at Kaklaya. It pounced on something and ate it up."

2127 hrs.

"On the way to Kadam Kunj saw a jungle cat on the road before the turning to python point. A porcupine came out with the jungle cat from the wetlands onto the road. The cat watched the porcupine, which was running. The cat stayed on the road (with the jeep following it). It suddenly stopped, pounced on an insect, caught it, in its mouth, looked around, then ate it up. It then entered the wetlands and went away."

2138 hrs.

"Fishing cat sighted near the pool of water where the pair of fishing cats were seen yesterday. Could be one of the two, when the jeep turned round the corner, we heard a splash and saw the cat come out of the water pool. It walked, turned around, sat down and watched us for a few minutes. It was only around 20 m from us. Bhulu was making "shrew like" shrill sounds. The cat..."
was staring at us and sat there for almost 10 minutes, just observing us."

4th June 1969
1945 hrs.

"Jungle cat sitting in the wetlands not far from the water pool where the fishing cats were sighted two days of and yesterday. It was resting with its paws tucked in. It was there for around 15 minutes, then got up and walked away."

2230 hrs.

"Jungle cat walking towards the pool of water (same cat ?) Stopped, stared at us for some time and then ran away."

10th June 1969
2135 - 2150 hrs.

"Observed a jungle cat hunting next to Bison Mori where the jackal was seen fishing a few weeks ago. The cat was sitting in a crouched position and eating. Then it sat up looked around, twitched its ears and pounced on something. It carried it little further and ate it up. It went to another spot and sat with forelimbs tucked in, looked around, got up and started running around fast, catching something ??). It caught it and ate it up. I assumed they were insects. It caught around 10 of these and ate them up. After some time it went away."

11th June 1969
1900 hrs.

"Went to the spot where the jungle cat was catching 'insects' and saw plenty (54 + around my foot) of very small frogs. It was probably catching these."

"
18th June 1989
1900 hrs.

"Six jackals seen on the road near the main entrance. Four of them were pups and they were running about and playing".

1950 hrs.

"Went to the canal and saw a jungle cat walking in the wetlands. It saw us and came towards us. It was around 20 m from us when a hare came out from behind some thickets and ran past the cat. The cat started stalking the hare, but suddenly stopped short when it was fairly close to the hare and instead went to a bush and rubbed its cheek on a twig that was sticking out. As it was doing this, its tail was held up and twitching".

23rd June 1989
2005 hrs.

"One of the tall grassland searches, we heard a distinct "meow" of a cat. It sounded hoarse but was not caterwauling. The guards at the chowki said it was a jungle cat. We followed the calls and saw the cat sitting on a clump of grass. It saw us, crouched down and ran away".

24th June 1989
1955 hrs.

"While doing a random search in the wetlands near Kadam Kunj, a small jungle cat. It ran over a mound and we saw it again at the edge of the wetlands near the road. Lapwings were giving an alarm call".
2010 hrs.

"Saw a jungle cat (larger than the first?) It was catching frogs? insects? on bare, cracked ground. Watched it for about 15 minutes."

1930 hrs.

"Fishing cat on road close to Kadam Kun. It ran into the wetlands. We followed it and saw it sitting under a tree with ears flattened on its head (angry?). It then ran away."

2015 hrs.

"Lapwings giving an alarm call near Keoladeo temple. Went to investigate and found four jackals (two pups, two adults)"

26th June 1989
2025 hrs.

"Heard a jungle cat call loudly in the short grasslands, near trail three. We followed the calls and the jungle cat came out on the road and sat down, watching us. It then went behind a bush, stuck its head out from the side and came out again. It sat down and observed us for around 5 minutes. It then started sniffing a twig and wailed away. We could hear it calling loudly again."

1st July 1989
0820 hrs.

"Near Bokalava, a jackal was seen getting down one of the mounds in the wetland into a pool of water. It waded in the water (coming up to its stomach) and went to the edge of the pool. On the way there were many small birds eg. lapwings, egrets, pond herons but it ignored them. It dug around in the wet soil with"
its forelimbs, picked out a large (one foot) dead fish and ran up on a mound. While it was running, lapwings (two) were mobbing it and calling (alarm call) loudly".

5th July 1989
1830 hrs.

"Two jackals seen opposite Sapan Mori wetlands. One of them sprayed on a clump of grass and then kicked with hind legs (as seen in dogs). The other sniffed at the sprayed clump and it too on it and kicked the grass with its hind legs. Then both of them ran away. Lapwings were giving alarm calls".

10th July 1989
2230 hrs.

"Fishing cat seen in the canal sitting at the edge of the water. It ran away on seeing me".

2330 hrs.

"Fishing cat returned and sat at the edge of the water again, concentrating hard at something in the water. It felt my presence and looked up and ran up and hid under a bush".

17th July 1989
2005 hrs.

"Jungle cat with a kitten sighted near the cycle repair shop (barrier). The kitten (about four months old if compared with domestic cats) was sitting and eating something while its mother was starting and watching it. The adult female looked very small the thin (very young?)".
18th July 1989
1955 hrs.

"Jungle cat with kitten seen near the cycle repair shop. Cat was sleeping on a mound of mud while kitten was sitting. The cat got up and started walking toward the mixed forests ('B' block). Kitten followed with tail raised up and swishing. While walking it was pouncing on its mother's tail (playing). If the kitten was left behind, the adult female used to wait for it to catch up."

19th July 1989
1945 hrs.

"House cat with a kitten (3-4 months old) sitting in the same place (mound) where the jungle cat was sitting with its kitten yesterday."

23rd July 1989
2045 - 2055 hrs.

"As I was just completing a search in the wetlands, I saw a jungle cat sitting on a trunk of a tree at Bakelaya. It got down and came on the road. It was probably a juvenile as it was small (size of a small house cat - 1 1/2 foot body length) and had faint spots on its body. It was less than 5 mts from me but did not notice me. It caught two on the road and ate them up. Then it turned around and saw my cycle. It stared for a while, then came to investigate. It sniffed at the wheels (distance of the cat from me was about 2 feet). It looked up saw me and ran and hid under a bush and was observing me."

1st August 1989

"Fishing cat seen at the canal for nearly the entire month."

..
17th August 1989
1945 hrs.

"I had been waiting at the canal from 1900 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
1800 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

\[ R_s = 1 - \frac{6 \sum d_i^2}{N^3 - N} \]

Where \( d_i \) = 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

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

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

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 (separately) 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.